C 55.10:974

Federal Plan for Marine Environmental Prediction

FISCAL YEAR 1974

FEDERAL COORDINATOR FOR
MARINE ENVIRONMENTAL
PREDICTION

PENNSYLVANIA STATE UNIVERSITY
DEC 27 1973
DOCUMENTS COLLECTION

FEDERAL COORDINATOR

Clayton E. Jensen

INTERAGENCY COMMITTEE FOR MARINE ENVIRONMENTAL PREDICTION

M. Grant Gross, Chairman

Robert C. Junghans
Department of Commerce

Cdr. Jack E. Geary
Department of Defense

Joseph E. Upson
Department of the Interior

Henry S. Andersen
Department of State

Capt. Rudolph E. Lenczyk
Department of Transportation

William O. Forster
Atomic Energy Commission

Willis B. Foster
Environmental Protection Agency

Morris Tepper
National Aeronautics and Space Administration

Albert P. Crary
National Science Foundation

David K. Young
Smithsonian Institution

Col. James L. Trayers (Observer)
Council on Environmental Quality

Harold S. Bassett (Observer)
Office of Management and Budget

F. Gilman Blake (Observer)
Office of Science and Technology

Cdr. William R. Curtis, Secretary

For sale by the Superintendent of Documents, U.S. Government Printing Office,
Washington, D.C. 20402—Price $0.70

U.S. DEPARTMENT OF COMMERCE
Frederick B. Dent, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator

FEDERAL COORDINATOR FOR
MARINE ENVIRONMENTAL
PREDICTION

INTERAGENCY COMMITTEE FOR
MARINE ENVIRONMENTAL
PREDICTION

FEDERAL PLAN FOR MARINE ENVIRONMENTAL PREDICTION

FISCAL YEAR 1974

WASHINGTON, D. C.
July 1973

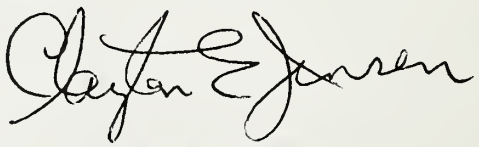
U. S. Depository Copy

PREFACE

This Federal Plan is published to provide the executive and legislative branches with a summary of Marine Environmental Prediction (MAREP) services and of research and development programs to improve those services. It will be used within the Federal Government to coordinate and plan MAREP services and research and is available outside the Government to identify means for utilizing the MAREP services and research activities. Coordinating the Government MAREP activities and preparing and maintaining the Federal Plan are performed by the Interagency Committee for Marine Environmental Prediction.

This Plan covers basic programs for fiscal year 1973 and increases in fiscal year 1974 for all participating Federal agencies. DATA for FY 1974 are those included in the President's FY 1974 budget submission to Congress.

In the first section, new thrusts for safety at sea and protection of the marine environment are highlighted. For example, a National Program for a Continuing Environmental Monitoring System for the Marine Leg of the Trans-Alaska Pipeline System (TAPS) is defined, and progress in international oceanographic cooperation is outlined. The second section summarizes agency expenditures supporting MAREP. The third describes the Basic MAREP Service, a program for fundamental observations and forecasts applicable to a wide variety of users. In the fourth section, Specialized MAREP Services for maritime navigation, water pollution assessment, living marine resources, ocean engineering, and national security are described. The final section covers research and development to improve MAREP services.



Clayton E. Jensen
Federal Coordinator for
Marine Environmental Prediction

CONTENTS

	Page
Overview	1
Summary of fiscal data	6
Basic Marine Environmental Prediction Service	9
Introduction	9
Description	9
Plans for improvement	10
Specialized Marine Environmental Prediction Services	12
Specialized MAREP Service for Maritime Navigation	12
Introduction	12
Description	12
Plans for improvement	13
Specialized MAREP Service for Water Pollution Assessment	13
Introduction	13
Description	14
Plans for improvement	17
Specialized MAREP Service for Living Marine Resources	18
Introduction	18
Description	18
Plans for improvement	19
Specialized MAREP Service for Ocean Engineering	21
Specialized MAREP Service for National Security	21
Research relevant to Marine Environmental Prediction	24
Introduction	24
Improvement of MAREP functions	24
Data acquisition	24
Information processing and dissemination	26
Understanding basic marine processes	27
Physical processes	27
Biological and chemical processes	30
Geographic areas of special interest	31
Coastal zone	31
Chesapeake Bay	34
Great Lakes	34
The Arctic	36
The Antarctic	38

Overview

Although man has made increased use of the oceans for transportation, food, recreation, and security, many of the natural dangers and mysteries of the ocean remain. Indeed, little more than the surface of this vast frontier has been studied. Recently it has become apparent that one of the most pressing questions is the effect that man himself has on his environment. The answers to current questions about the hydrosphere in general require analysis or interpretations of much data over large areas.

The marine environment is being subjected to man's influences on an ever-increasing scale. Because of the lack of knowledge of the consequences, there is a need for marine environmental monitoring and prediction information to insure the efficient and beneficial uses of the oceans for transportation, recreation, food, and minerals for the Nation.

If the Nation is to effectively utilize, control, and manage the marine environment, it must satisfy the urgent and economically important needs for scientific information on the marine environment and its physical, chemical, and biological constituents. As the Senate Commerce Committee observed, ". . . Realization of the full potential of the oceans will require a long-term program of exploration, observation, and study on a worldwide basis." [1]

The goals of Federal marine environmental monitoring, taking advantage of the technological capacity of private industry and the cooperation of other nations, are threefold:

1. To provide an integrated program for marine prediction and information services, including timely warnings of hazardous environmental conditions, both natural and manmade, for the protection of life and property and for efficiency of maritime operations on the high seas, in coastal waters, and on the Great Lakes.

2. To develop and maintain an integrated environmental monitoring system that will effectively satisfy the needs for physical, chemical, and certain biological and geological data from oceanic and coastal regions to support service-oriented programs and to facilitate control of environmental pollution.

3. To support assessments and predictions of the distribution and abundance of those living marine resources of principal importance to the United States.

Thus Marine Environmental Prediction (MAREP) is defined here as the monitoring, assessing, and forecasting of the physical, chemical, biological, and hydrodynamic states of the ocean and its interaction with the overlying atmosphere and adjacent terrestrial boundaries. The marine environment is broadly interpreted to include the open oceans and seas, the Great Lakes, and all air, sea, and land interactions in coastal regions that include marine-related variables.

Several instruments of legislation enacted by the 92nd Congress have significant impact on Federal planning for MAREP. The Marine Protection, Research, and Sanctuaries Act of 1972 prohibits the dumping of most materials in the ocean unless a permit is granted by the Environmental Protection Agency or the Army Corps of Engineers. Title II of that measure mandates to the National Oceanic and Atmospheric Administration a program of comprehensive research and monitoring on ocean dumping. The Federal Water Pollution Control Act Amendments of 1972 require the establishment and equipping of a water quality surveillance network not only for the Nation's fresh water resources but also for the coastal zone and oceans. This bill also requires permits for marine waste disposal. The Federal Coastal Zone Management Act of 1972 will encourage long-term planning and management of invaluable and irreplaceable coastal resources. Sound marine environmental predictions programs and plans must be a definite part of the implementation of the above-mentioned legislation.

To meet the responsibility for MAREP in the oceanic environment, including the marine atmos-

[1] U.S. Congress, Senate, Committee on Commerce, *Ocean Exploration*, 90th Congress, 2nd sess., July 26, 1968, 5 Rept. 1476, p. 3.

phere, the Interagency Committee for Marine Environmental Prediction (ICMAREP) is developing programs for oceanic monitoring, assessment, and prediction. The need for such programs was emphasized in 1969 by the Commission on Marine Science, Engineering and Resources (Stratton Commission) which noted, "The Nation must have a comprehensive system for monitoring and predicting the state of the oceans and atmosphere." Hence, the goal of the ICMAREP programs is a framework for coordinated national effort, public and private, and leadership in maximizing these assessment and predictive services to all users.

The national program is to provide the following oceanic services:

- Warnings and forecasts of natural oceanic hazards
- Environmental data needed for marine resources management
- Assessments of oceanic pollution
- Environmental information for national security and coastal zone management

Thus the oceanic monitoring, assessment, and prediction concept has been designed to coordinate the capabilities and resources of Federal agencies and, where feasible, those of local governments, universities, and private industry toward meeting the Nation's needs for ocean-related environmental services. Better information and predictions of the ocean's physical, chemical, and biological conditions will provide support for more effective management of marine resources, including fisheries, ocean dumping, recreational boating, surfing, offshore development, and commercial shipping.

Facilities of several Federal agencies and the private sector will be involved. Success of the program depends also on cooperation extended by commercial ship operators for gathering marine observations. In addition to those of NOAA, resources of Federal agencies include ships, aircraft, communications stations of the Coast Guard, selected facilities of the Department of Defense, and EPA laboratories.

As an example, the Nation's energy situation draws more attention to the need for environmental impact statements, oceanic monitoring, assessment, and prediction services to support offshore and engineering development, safe tanker transits, and efficient harbor and terminal operations. Increased shipping of energy-producing materials, such as oil and gas, is expected, and additional sources will be sought to meet steadily growing national needs.

Improved environmental monitoring and prediction must be available for more effective implementation of the National Contingency Plan for Oil and Hazardous Substances Pollution. Detection and reporting of pollutants by Government ships and ships-of-opportunity will be supplemented by aircraft and satellite observations. Special small-area wind and wave forecasts would be required by the National Response Teams in event of an oil spill, and the local current pattern would be needed to predict the dispersion of the pollutant.

Services supporting the Trans-Alaska Pipeline—Services for the Trans-Alaska Pipeline System (TAPS) will form the first regional implementation of an oceanic monitoring, assessment, and prediction concept. Environmental support for TAPS is intended to assist in transporting the oil over the ocean route by assuring safer navigation and better cargo protection from the marine environment. From the pipeline's southern terminus at Port Valdez, on Prince William Sound, tankers will transport oil across the Gulf of Alaska to west coast ports. Considering the environmental concerns, the Secretary of the Interior outlined several steps to be taken in implementing TAPS, including the following:

> "A continuing environmental monitoring system will be required during the lifetime of oil movement in American coastal waters."

The Federal Task Force on Alaskan Oil Development has designated the National Oceanic and Atmospheric Administration (NOAA) as lead agency for development of a marine environmental services program that would respond to the expressed need for "a continuing environmental monitoring system" to support operations on the marine leg of TAPS. These services will be provided by implementing the oceanic monitoring, assessment, and prediction concept in the northeastern Pacific Ocean area. Other Federal agencies involved in monitoring and regulatory functions include the Department of Transportation (Coast Guard) and the Environmental Protection Agency. Various supporting functions may also be provided by the National Aeronautics and Space Administration, Smithsonian Institution, and the Department of State.

The types of environmental support needed for the marine leg of TAPS include weather advisories, predictions, and warnings of day-to-day hazardous conditions; all of which relate to safety of lives, protection of equipment and cargo, harbor control decisions, and efficiency of ship and harbor operations. Such services for TAPS include information on:

—Tides, tidal currents, and anomalous currents in harbors and restricted waterways used by tankers and other ships

—Tsunamis and other anomalous water levels in harbors, anchorages, and critical navigational channels

—Harbor ice conditions

—Fog and other restrictions to visibility in harbors, waterways, and on the high sea routes

—Wind, sea, and swell including combined sea/swell heights, periods, and direction

—Wind-driven currents

—Water quality trend analyses

—Air, sea surface, and subsurface thermal structure

—Ice accretion on ships

—Other special services on a case-by-case basis

To support the assessment, prediction, and warning services for TAPS, the monitoring functions must include seismic, oceanographic (including water quality), and atmospheric measurements of the immediate and adjacent environmental regime. Services should involve where practicable and useful a variety of platforms including ships, buoys, satellites, aircraft, and coastal stations. Existing monitoring systems are largely surface oriented. Atmospheric measurements will be augmented along with limited oceanographic measurements at the earliest date practicable.

Monitoring functions are prescribed by the information needs of the users for predictions and warnings based on the analyses of operational models. Research programs directed to the causes and effects of environmental change are used to improve these services. In this regard, regional projects, such as those under NOAA's Marine Ecosystem Analysis (MESA) program and the North Pacific Experiment (NORPAX) sponsored by NSF and ONR, are important. MESA is a prototype study which is being implemented in the New York Bight to better understand the fate and distribution of marine contaminents. NORPAX will study sea-air interaction for an area of the North Pacific Ocean to improve our understanding of oceanic effects of long-term trends of U.S. climate.

Ongoing Federal activities—The extent of Federal responsibility for MAREP products, services, research, and technology reflects response to a wide range of current and potential user needs. The Departments of Commerce, Defense, Interior, and Transportation, together with the Enviromental Protection Agency (EPA), the Atomic Energy Commission (AEC), the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the Smithsonian Institution either conduct or fund work related to MAREP. The Interagency Committee for Marine Environmental Prediction, formed in 1970 to coordinate planning of MAREP services, to prevent overlapping of products and services, and to promote advanced MAREP services and relevant research, is composed of the nine Federal agencies mentioned above plus the Department of State. ICMAREP has the following subcommittees and task groups to address diverse problems and to assist in preparing plans dealing with specific aspects of MAREP.

- The Subcommittee on Marine Baselines and Monitoring has initiated a plan for a multiphased and dynamic marine environmental quality program, with the initial phase devoted to the identification of national and Federal needs and description of available capabilities. The goal of the Plan is to establish environmental baselines and to measure the parameters needed to continually assess the nature, extent, and rate of environmental change in coastal, estuarine, and selected ocean areas.

- The Subcommittee for the Integrated Global Ocean Station System (IGOSS) links the national aspects of MAREP with the international marine programs. IGOSS is a United Nations program under the Intergovernmental Oceanographic Commission (IOC) and in many ways an international counterpart of MAREP. Through the Subcommittee for IGOSS, information on Federal programs and techniques is coordinated to provide national inputs to the international program. The present IGOSS pilot project for collection, exchange, and evaluation of bathythermograph data is an example. Details for a pilot project to monitor marine pollution are under development.

- The Subgroup on Buoys was established in 1970 to coordinate environmental data buoy programs for Federal agencies. Present capabilities and plans for the future will be outlined in the *Federal Plan for Environmental Data Buoys* now under preparation.

International activities—The recognition that environmental problems can no longer be solved solely by nations on their own has led to steadily increasing international cooperation in marine environmental activities. With brief historical notes, this section will mention the progress by the United States in international oceanographic cooperation since last year's Federal Plan for MAREP was published.

In 1969 the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) was established by specialized agencies of the United Nations. GESAMP was charged with advising on the scientific and technical aspects of marine pollution and developing proposals for cooperative programs of pollution monitoring and abatement.

At its Seventh Session, during October-November 1972, the Intergovernmental Oceanographic Commission (IOC) declared itself to be the appropriate body within the UN system for planning and coordinating a program of marine pollution monitoring. At the same session the Commission agreed to develop the Global Investigation of Pollution in the

Marine Environment (GIPME) as one of the major projects of the International Decade of Ocean Exploration (IDOE). The scientific advisory bodies to the Commission recommended that programs within GIPME consider the feasibility of a study of river inputs to ocean systems, encourage and coordinate national and regional programs for baseline studies of marine pollution, and give high priority to the creation of cooperating laboratories for determining the concentrations and effects of chemical pollutants in sea water and marine organisms and sediments.

At its Seventh Session the IOC also endorsed the establishment of an international marine pollution monitoring program within the framework of the Integrated Global Ocean Station System (IGOSS). The IGOSS program, for which planning was begun in 1967, is intended to provide a variety of operational products resulting from observation, assessment, and prediction of the marine environment. In early 1972 an IGOSS pilot project for the collection, exchange, and evaluation of bathythermograph data was instituted. IGOSS is being developed in close conjunction with the World Weather Watch of the World Meteorological Organization (WMO). The Global Telecommunications System of the World Weather Watch is the principal means for international operational data exchange for the project.

The United Nations Conference on the Human Environment at Stockholm, June 1972, encouraged and provided guidelines for action by governments and international organizations to protect and improve the human environment. The Conference's recommendations concerning the marine environment were that:

1. Governments "support national research and monitoring efforts that contribute to agreed international programs for research and monitoring in the marine environment, in particular GIPME and IGOSS."
2. IOC and WMO, in cooperation with other interested intergovernmental bodies, promote the monitoring of marine pollution, preferably within the framework of IGOSS, as well as the development of methods for montoring high-priority marine pollutants in the water, sediments, and organisms.
3. IOC insure that provisions are made for international exchange and dissemination of data on baselines and marine pollution and that attention is paid to the special needs of developing countries.
4. Governments take early action to control significant sources of marine pollution.
5. The convention on ocean dumping proposed by the United States be negotiated and opened for signature before the end of 1972.

At its first session in June 1972, the Joint IOC/WMO Planning Group for IGOSS, acting on the recommendations of the Seventh Session of the IOC, the UN Conference on the Human Environment, and the Executive Committee of the WMO, began preparing for the IGOSS pilot project on marine pollution monitoring. The Joint Planning Group emphasized that a global marine pollution monitoring system should evolve through the progressive combination of national programs into regional programs and regional programs into an international effort. Because national programs constitute the basic units of a global program, nations that do not have monitoring programs were encouraged to develop them. Moreover, the Joint Planning Group recommended an inventory of existing national monitoring programs and that nations that develop monitoring programs in the future be encouraged to use the experience gained through the inventory. The Planning Group envisioned the stations of a global marine pollution monitoring system as falling into two basic categories—impact stations and reference stations. Impact stations will be located in areas where the introduction of pollutants is considerable or likely to be particularly harmful to living resources. Reference stations will be located where human influence is minimal in order to follow large-scale changes, particularly those resulting from the transport of pollutants over great distances by both the sea and the atmosphere.

In July 1972 the Executive Council of the IOC established the International Coordination Group (ICG) for GIPME, specifying that each member of the ICG is to be a scientist actively involved in marine pollution research or monitoring programs. The ICG is charged with preparing a comprehensive plan for implementation of GIPME.

A United States initiative for an ocean dumping convention resulted in the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. The Convention was developed at the Intergovernmental Conference on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter held in London during October-November 1972 and opened for signature on December 29. The Convention regulates the dumping of wastes at sea from vessels, aircraft, platforms, and other manmade structures when the wastes are not derived from the normal operations of such craft. The Convention recognizes the importance of international cooperation in monitoring and scientific research and invites advice on scientific or technical

aspects of the Convention from appropriate scientific bodies.

Cooperation in other areas of marine environmental prediction and monitoring has also been advanced by various bilateral arrangements. At the first meeting of the U.S.-Soviet Joint Committee on Cooperation in the Field of Environmental Protection, held in Moscow, September 18–21, 1972, agreement was reached on several projects involving the marine environment. The Joint Committee was established by the U.S./U.S.S.R. Agreement on Cooperation in the Field of Environmental Protection, signed in Moscow on May 23, 1972, by President Nixon and Chairman N. V. Podgorny of the Presidium of the Supreme Soviet. Included in this agreement are that:

1. The United States and the Soviet Union will designate lakes and estuaries for joint projects on water pollution. Lake Baikal in the Soviet Union, Lake Tahoe, and one of the Great Lakes will be studied. Both nations will also exchange information on the chemical aspects of marine pollution and the effects of pollutants on marine organisms.
2. Both nations will exchange tsunami information and will consider the possible integration of the tsunami warning systems operated by the U.S. in the area of Hawaii and by the U.S.S.R. in the area of Kurile-Kamchatka.

In addition to the recently signed bilateral agreement with the U.S.S.R., the U.S. has a long-standing agreement with Japan on natural resources. The United States-Japanese Cooperative Program in National Resources Development includes a panel on Marine Environmental Observation and Forecasting. A Joint United States-Japanese meeting of the panel was held in Washington, D.C., on November 20–21, 1972, and discussed cooperation in marine monitoring and prediction services and research and development. Also, exchanges between the United States and France are in progress in the areas of buoy technology and instrumentation standards. The Arctic Ice Dynamics Joint Experiment (AIDEX), involving the U.S. and Canada, will be the first step in the international Polar Experiment (POLEX).

Summary of Fiscal Data

The following tables summarize fiscal information for programs of the Federal Government associated with Marine Environmental Prediction (MAREP) as proposed in the President's fiscal year 1974 budget. The funds shown are those used to provide services and to support relevant research that has both long-term and short-term objectives for improving services. Information on observations made from land and marine stations for the unique purpose of collecting data for the Basic Meteorological Service is not included in this Plan, but is reported in the annual *Federal Plan for Meteorological Services and Supporting Research*. The Marine Meteorological Service, discussed as a Specialized Meteorological Service in the above Plan, is included as an integral part of this Plan for MAREP; appropriate sections contain funding information for and descriptions of the Marine Meteorological Service.

The fiscal information for operations in MAREP and for relevant research is presented by agency and by service in tables 1 and 2. Data for FY 1973 programs and for planned activities in FY 1974 are included as proposed in the President's budget. The total Federal expenditure in MAREP planned for FY 1974 is $206,337,000 with an increase of $13,237,000 over FY 1973. Most Federal agencies plan activities at level funding or with modest increases.

In the operations area, total MAREP costs for FY 1974 are expected to be $96,260,000, a net increase of $9,653,000 over FY 1973. The largest planned increases are those of the Department of Commerce.

The planned expenditures for FY 1974 research and development programs relevant to MAREP services total $110,077,000, showing an increase of $3,584,000 over FY 1973.

The major Department of Commerce FY 1973–74 increases are accounted for by expanded efforts in

Table 1.—Federal funding for Marine Environmental Prediction, by agency

[Thousands of dollars]

Agency	Operations			Research			Total		
	FY 73	FY 74	Difference	FY 73	FY 74	Difference	FY 73	FY 74	Difference
Commerce	39,457	45,170	+5,713	50,321	53,741	+3,420	89,778	98,911	+9,133
Defense	27,432	30,652	+3,220	18,988	20,134	+1,146	46,420	50,786	+4,366
Interior	1,250	1,250		1,887	1,917	+ 30	3,137	3,167	+ 30
Transportation	10,783	11,102	+ 319	3,687	3,960	+ 273	14,470	15,062	+ 592
AEC				4,846	5,523	+ 677	4,846	5,523	+ 677
EPA	6,323	6,724	+ 401	4,431	4,833	+ 402	10,754	11,557	+ 803
NASA				4,001	2,875	−1,126	4,001	2,875	−1,126
NSF				16,575	15,337	−1,238	16,575	15,337	−1,238
Smithsonian	1,362	1,362		1,757	1,757		3,119	3,119	
Total	86,607	96,260	+9,653	106,493	110,077	+3,584	193,100	206,337	+13,237

Table 2.—Federal funding for Marine Environmental Prediction, by service

[Thousands of dollars]

Service	Operations			Research			Total		
	FY 73	FY 74	Difference	FY 73	FY 74	Difference	FY 73	FY 74	Difference
Basic	47,511	53,672	+6,161	58,415	60,538	+2,123	105,926	114,210	+8,284
Maritime navigation	6,142	5,749	− 393	816	1,210	+ 394	6,958	6,959	+ 1
Water pollution assessment	8,125	11,968	+3,843	13,250	12,938	− 312	21,375	24,906	+3,531
Living marine resources	6,589	6,722	+ 133	17,993	17,797	− 196	24,582	24,519	− 63
Ocean engineering				1,427	1,530	+ 103	1,427	1,530	+ 103
National security	18,240	18,149	− 91	14,592	16,064	+1,472	32,832	34,213	+1,381
Total	86,607	96,260	+9,653	106,493	110,077	+3,584	193,100	206,337	+13,237

Basic Environmental Satellite operations and support. Of the increase of $9,133,000, over half of this is attributable to satellite work. Other main increases include a $3,000,000 addition for GARP Atlantic Tropical Experiment (GATE) and $450,000 for Basic Observations and Communications. In addition, several new programs have been added to MAREP. With increases totaling $530,000 from FY 1973 to FY 1974 major new subactivities included are the Environmental Impact Analysis, MESA and Ocean Dumping, and River and Flood Forecast and Warning Services.

The major programs of the Federal agencies which contribute to the several MAREP services listed in table 2, are discussed, together with planned improvements, in succeeding sections of the Plan.

Table 3 shows the FY 1973 interagency transfers of funds for research related to marine environmental prediction.

Table 3. Interagency fund transfers for Marine Environmental Prediction,[1] fiscal year 1973

[Thousands of dollars]

Transferred from	Transferred to	Funds
NASA	Commerce	300
NSF	Commerce	325

[1] Research only.

Table 4.—Agency operational costs for Marine Environmental Prediction, by function

[Thousands of dollars]

Agency	Data acquisition		Communications		Data processing		Information dissemination		General agency support		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce	16,437	19,877	635	673	10,639	11,245	4,872	6,114	6,874	7,261	39,457	45,170
Defense	8,692	10,024	2,558	2,615	4,839	6,476	3,293	3,414	8,050	8,123	27,432	30,652
Interior	[1]1,125	[1]1,125							125	125	1,250	1,250
Transportation	8,871	8,759	155	163	750	750	345		662		10,783	
EPA							6,323	6,724			6,323	6,724
Smithsonian	[2]869	[2]869					293	293	200	200	1,362	1,362
Total	35,994	40,654	3,348	3,451	16,228	18,471	15,126	17,187	15,911	16,497	86,607	96,260

[1] Includes communications, data processing, and information dissemination.

[2] Includes data processing.

The MAREP products and services are generated through the operations of a system made up of four interlocking functions plus a support function. As treated in this Plan, these five functions are data acquisition, communications, data processing, information dissemination, and general agency support. These functions are further explained in the next section under the description of the Basic MAREP Service; however, a summary of fiscal information arranged according to functions is also given in tables 4 and 5. Tables showing agency support of the Basic and Specialized Services and Relevant Research are included in succeeding sections.

Table 5.—Agency manpower in Marine Environmental Prediction, by function

[Man-years]

Agency	Data acquisition		Communications		Data processing		Information dissemination		General agency support		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce	328	345	12	12	310	328	170	228	219	236	1,039	1,149
Defense	315	313	192	189	321	316	215	211	549	535	1,592	1,564
Interior	[1] 115	[1] 115							10	10	125	125
Transportation	1,027	975	10	10	68	68	9	9	56	56	1,170	1,118
EPA							30	30			30	30
Smithsonian	[2] 63	[2] 63					12	12	7	7	82	82
Total	1,848	1,811	214	211	669	712	436	490	841	844	4,038	4,068

[1] Includes communications, data processing, and information dissemination.

[2] Includes data processing.

Basic Marine Environmental Prediction Service

Introduction

The Basic MAREP Service provides fundamental observations and forecasts used by the general public, Government agencies, specialized user groups, and other segments of the economy. The Basic Service also provides many of the observations, analyses and forecasts, and communications needed to provide Specialized MAREP Services. Furthermore, it is recognized that certain meteorological observations, analysis and forecast centers, and their communication links, provided primarily for the Basic Meteorological Service, furnish invaluable support to the Basic and Specialized MAREP Services.[2]

The principal observation and communication networks, analysis and forecast activities, and related Federal activities which support the Basic MAREP Service are:

- Oceanographic and related meteorological observations using naval vessels, research ships, ships of opportunity, data buoys, and reconnaissance and patrol aircraft, fixed platforms, and vessels engaged in Standard Monitoring Sections, and other operations.
- Satellite programs for the remote sensing of the marine environment, with eventual extension to the collection and transmission of data from on-site platforms.
- Tropical region reconnaissance.
- Flights over the Atlantic and Pacific Oceans to collect sea surface temperature and bathythermograph (BT) data from which mean monthly sea surface temperature charts and Gulf Stream charts are produced.
- Cooperative tropical reconnaissance, analyses, and storm and hurricane warnings.
- The Pacific Tsunami Warning System.
- Special procedures activated by the National East Coast Winter Storm Operations Plan which depend upon cooperative reconnaissance and surface observation, analysis, and warning capabilities.
- Tide and tidal current prediction and Great Lakes water level monitoring services.
- Marine data collection, and relay by high-speed circuits and teletypewriter systems.
- Processing, analysis, and forecast centers for marine services.
- Dissemination of marine forecasts and warnings by means of continuous very high frequency/frequency modulation (VHF/FM) radio broadcasts.
- Storage and retrieval of marine data and publication of marine atlases.
- Monitoring of streamflow and water quality in estuaries and the Great Lakes.
- Hydraulic, hydrologic, and sedimentation study and flood management services.
- Establishment of techniques and secondary reference standards for the assessment of oceanographic instrument performance and for information on performance and on instrument development programs.
- Aircraft flights conducted over the Arctic Basin and adjacent areas to obtain quasisynoptic sea ice observations and related environmental data.
- Optimum track ship routing for defense-related activities.

[2] A full description of the Basic and Specialized Meteorological Services and Supporting Research is published annually by the Federal Coordinator for Meteorological Services and Supporting Research. The Basic and Specialized Meteorological Services and facilities will be referenced incidentally in this Plan as interface with MAREP services, except in the case of the Marine Meteorological Service and tropical cyclone warnings which are integral parts of MAREP services.

Description

MAREP has been defined as the monitoring, assessing, and forecasting of the physical, selected biological, chemical, and hydrodynamic states of the ocean and its interaction with the overlying atmosphere and adjacent terrestrial boundaries. It is therefore treated as a total system, made up of four

closely related functions: Data acquisition, communications, data processing, and information dissemination.

The processing and prediction function depends upon data acquisition involving sensing, measuring, or otherwise determining or describing the state of the ocean and its overlying atmosphere. Included are parameter measurements, data collection, recording, and processing; interfaces with communications systems; and deployment and maintenance of observational platforms. Observational platforms include shore stations, vessels, aircraft, fixed platforms, buoys, and satellites. Government vessels include naval, survey, research, and ocean station vessels, and cooperative merchant ships. Reconnaissance patrol and commercial aircraft provide marine data. Satellites are designed to provide remote sensing, and some to relay information from on-site measuring instruments.

Timeliness of MAREP operational services depends on minimum delay in transmitting raw data to processing centers, processed data between centers, and predictions, warnings, and other information to the user. Federal communication radio and landline networks are supplemented by commercial networks. This communication function includes message composition and formatting, handling, relaying, and receipt of data as well as the maintenance tasks directly related to communication systems.

An attendant category, general agency support, involves activities which agencies must perform such as training, maintenance of equipment and facilities, internal support, and management above the operating level so that the total system can be operated to provide MAREP services effectively and efficiently.

Detailed descriptions of the Basic MAREP Service are presented in *Federal Plan for Marine Environmental Prediction for Fiscal Year 1973,* issued in March 1972.

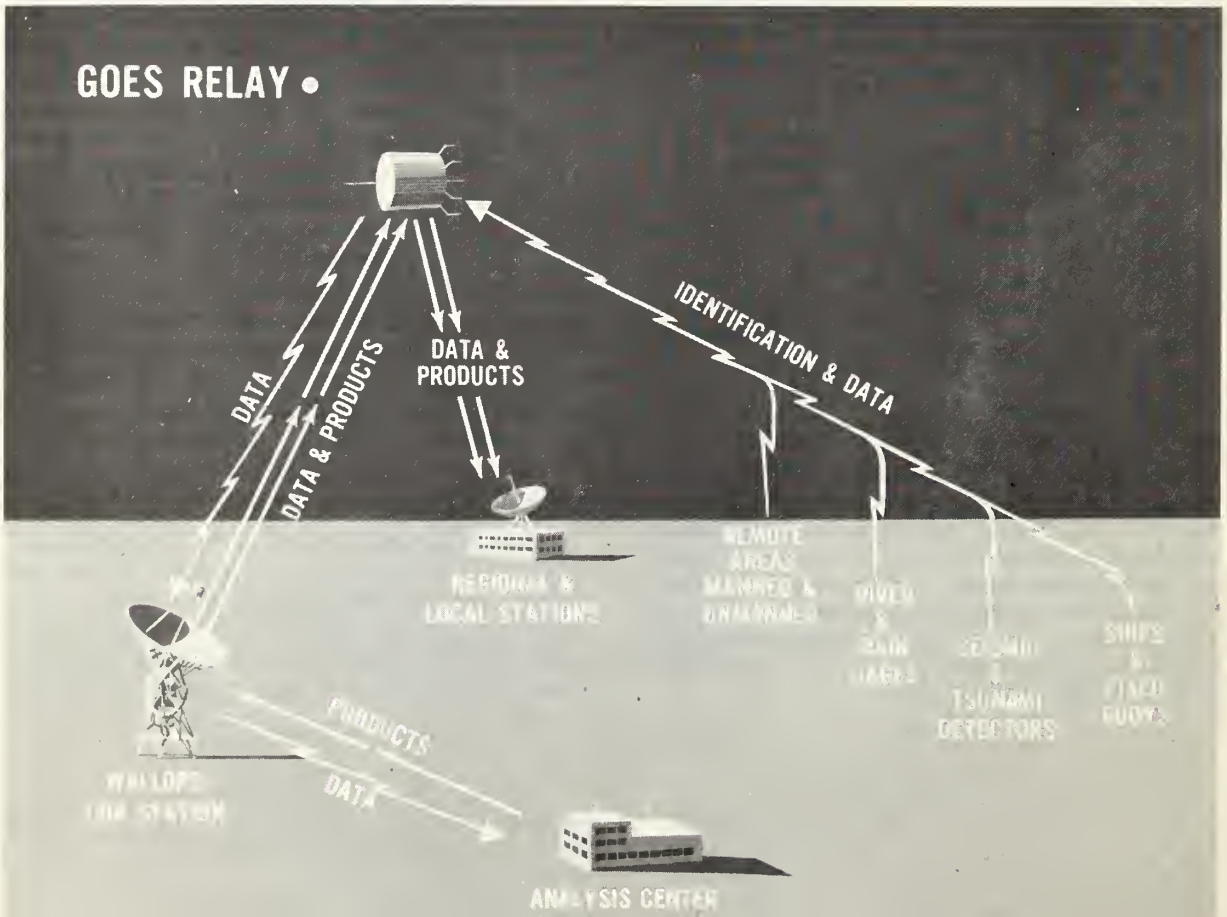
Plans for Improvement

Increases in FY 1974 are programmed for expansion of the Basic MAREP Service by providing replacement equipment, taking certain personnel actions, modifying and improving support and facilities, and improving the Service itself.

Following are areas in which significant improvements are planned:

- NASA will spend $6,000,000 early in FY 74 to launch the first Geostationary Operational Environmental Satellite (GOES) for NESS to provide near-continuous pictures and infrared images over North American and adjacent oceans (fig. 1).

Figure 1.—The GOES system will provide pictures and infrared imagery of North America and the adjacent oceans.



GOES is expected to significantly improve accuracy and completeness of sea surface temperature data obtained from satellite and will assist development of techniques for measuring sea state. GOES will be equipped to collect data from remote observational platforms including data buoys, tide stations, tsunami surveillance instruments, and ships at sea. The data will be transmitted to a data acquisition station at Wallops Island, Va., for further dissemination as required. The radio package to be mounted on the platform for communicating data to the satellite has been developed and is now in production.

- Satellite Field Service Stations are being established in conjunction with Weather Service Forecast Offices at San Francisco, Kansas City, Miami, and Washington to provide operational satellite data and services (primarily from GOES) directly to field users.
- NOAA will maintain an Environmental Data Index (ENDEX) to provide a searchable, fully documented, marine environmental data index or inventory of data holdings as a direct adjunct to holding the actual data. Used in a referral mode, ENDEX will bridge the gap between data collection and publication or archiving at a cost of $65,000.
- NOAA will convert the Great Lakes Special Project Office at NODC into a permanent office to provide a focus for limnological, climatological, marine geophysical-environmental data services for the Great Lakes Basin at a cost of $35,000.
- DOD will conduct a series of oceanic surveys by ships of opportunity between Halifax, Canada, and Bermuda, using expendable bathythermographs taken from periodic cruises to describe characteristics variability and movements of thermal features in this area.
- Purchase of a variety of oceanographic instruments costing $133,000 that are required to equip follow-on Navy reconnaissance aircraft.
- Development of stage-discharge relations in outflow rivers and determination of effects on levels and outflow of the Great Lakes by the Corps of Engineers, requiring $64,000 in new funds.
- Improvement in technical services to State and local governments by the Corps of Engineers, costing an additional $60,000.
- Expansion of the environmental data collection program of the Corps of Engineers to improve baseline data for engineering analysis in planning, design, construction, operation, and maintenance of projects through use of remote-sensing techniques.

The principal decrease in FY 1974 funding for MAREP services has resulted from the disestablishment of Ocean Station Vessel Program (maintaining only Ocean Weather Station HOTEL) and subsequent decommissioning of vessels by the Coast Guard between October and April.

Specialized Marine Environmental Prediction Service

As noted in the preceding chapter, the Basic MAREP Service provides support for Specialized MAREP Services which include those for maritime navigation, water pollution assessment, living marine resources, ocean engineering, and national security. Specialized MAREP Services will be described in this chapter along with planned improvements in their operational programs. Research designed to improve MAREP services will be identified in the final section of this Plan.

SPECIALIZED MAREP SERVICE FOR MARITIME NAVIGATION

Introduction

Because of their applicability to a variety of users and their support of other Specialized MAREP Services, many Federal operations are considered integral parts of the Basic MAREP Service, yet they are particularly significant to maritime navigation. All marine forecasts, advisories, and warnings produced under the Marine Meteorological Service are important for ship operators. The shipping industry, fishing fleets, and recreational boatmen use these products as applicable to protect life, increase ship's safety, and to minimize damage to vessels and cargo by altering ship tracks for optimum transit between ports. Elements of the Basic MAREP Service useful to maritime navigation include sea-and-swell forecasts, storm surge and seiche forecasts, tropical and extratropical storm forecasts, and studies of sedimentation in channels and harbors. Also of primary importance are marine atlases, sailing directions, tide and tidal current prediction tables, and other special publications. Conversely, nautical charts, navigational tables, periodic navigational publications, and electronic navigation materials are not considered part of these MAREP Services and are not included in this Plan.

Description

Programs of the Departments of Commerce, Defense, and Transportation which uniquely serve the specialized requirements of a MAREP Service for Maritime Navigation include ice forecasts and warnings and ship routing and channel maintenance services. Agency funding of the MAREP Service for Maritime Navigation is shown in table 6.

The Department of Defense observes and forecasts sea ice by assigning Naval Weather Service ice observers on ice reconnaissance flights and through BIRDSEYE flights. Ice reconnaissance missions are coordinated and scheduled by Fleet Weather Facility,

Table 6.—Funding of Marine Environmental Prediction Service for maritime navigation, by agency,

[Thousands of dollars]

Agency	Operations		Research		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce	1,678	1,678			1,678	1,678
Defense	2,893	2,957	187	245	3,080	3,202
Transportation	1,571	1,114	170	215	1,741	1,329
NASA			459	750	459	750
Total	6,142	5,749	816	1,210	6,958	6,959

Suitland (FLEWEAFAC Suitland), and BIRDSEYE flights coordinated by the Naval Oceanographic Office (NAVOCEANO). In addition, ice observers fly aboard other Navy, Coast Guard, and Air Force aircraft, recording ice conditions on a not-to-interfere basis. FLEWEAFAC Suitland provides operational sea ice forecasts to operating units of the Navy, Coast Guard, and research agencies involved in Arctic and Antarctic operations. Sea ice forecasts include routing recommendations while forces operate in or near ice packs. FLEWEAFAC Suitland also transmits weekly messages describing ice conditions around the entire Arctic on a yearly basis and for the Antarctic from October through March; charts of these ice conditions are also mailed to requesting agencies. Numerical ice drift vector procedure, developed in-house to forecast ice drift by combining wind and ocean currents, is utilized by FLEWEAFAC Suitland in the production of ice forecasts.

NAVOCEANO prepares experimental short-range and long-range (15- and 30-day) ice forecasts in support of ship operations conducted by Defense, Coast Guard, and other Federal agencies. These forecasts include data on initial formation, growth, movement, and decay of sea ice in selected Arctic and Antarctic Ocean areas.

A seasonal ice outlook, describing the ice conditions expected throughout the shipping season, is also prepared for selected areas. NAVOCEANO is also preparing a series of ice forecasting manuals for the Arctic and Antarctic regions and developing computer programs for predicting ice thickness. An experimental ocean frontal analysis chart, covering the Gulf Stream, slope water, and Continental shelf area in the northwest North Atlantic, is also prepared and transmitted to Fleet Weather Central Norfolk by NAVOCEANO for use in fleet products.

The Fleet Numerical Weather Central (FNWC) at Monterey and Fleet Weather Central Norfolk operate the U.S. Navy Optimum Track Ship Routing (OTSR) program. The OTSR program offers a high probability of one or a combination of the following: (1) Reduced time en route, (2) best weather en route, and (3) bypassing storm areas where damage to ship or cargo may be expected. This service is available to naval ships, to Military Sea Transportation Service ships, and to vessels under contract to the Government. The Navy OTSR program provided routing services for approximately 1,950 voyages during calendar year 1972. Major processing activities provide over 3,000 separate oceanographic prediction products daily to meet existing requirements.

The Coast Guard operates the International Ice Patrol, established by the maritime nations of the Inter-Governmental Maritime Consultative Organization (IMCO), to advise ships of icebergs in the northwestern North Atlantic Ocean. Aircraft reconnaissance and shipboard oceanographic observations support a program of reporting icebergs that enter the shipping lane near the Grand Banks of Newfoundland and of predicting their drift.

As part of a multiagency effort to extend the Great Lakes navigation season further into the winter, NASA and the Coast Guard will fly Side-Looking Airborne Radar (SLAR) over all critical areas in the Great Lakes. From the SLAR imagery (fig. 2) ice forecasts will be made available to shipping.

The Department of Commerce, through its National Weather Service (NWS), cooperates with Defense and Transportation in monitoring and predicting ice coverage and movement in the Great Lakes as well as in the Arctic Ocean off the North Slope, in Cook Inlet, and in other Alaskan waters. The NWS provides data and analyses that support ship routing services to civilian merchant ships. NESS provides facsimile ice warning services for the Alaskan waters based on data from a satellite Very High Resolution Radiometer. Data from this radiometer are also used to assist NWS in other areas of analysis.

Plans for Improvement

In the Department of Defense the Army plans to improve, over the next few years, services necessary to extend the navigation season in the Great Lakes and St. Lawrence Seaway. This program should also result in improved predictions for snow, ice, and ice fog around the Lakes. An interagency group has been established under the lead of the Army Corps of Engineers to develop plans to demonstrate the feasibility of extending the navigation season. The Corps also intends to determine which deep-water ports will permit the use of deep-draft bulk carriers. These studies will include consideration of requirements for expanded environmental prediction services. Prediction services will also benefit from continuing Navy support begun in FY 1973 from development and improvement of satellite positioning systems. NAVOCEANO will continue development of an automated ice-data archive, permitting rapid access to ice information for the Arctic and the Antarctic as obtained from ship, shore station, and aircraft.

SPECIALIZED MAREP SERVICE FOR WATER POLLUTION ASSESSMENT

Introduction

Water pollution is of great concern, particularly in estuaries, the coastal zone, and the Great Lakes

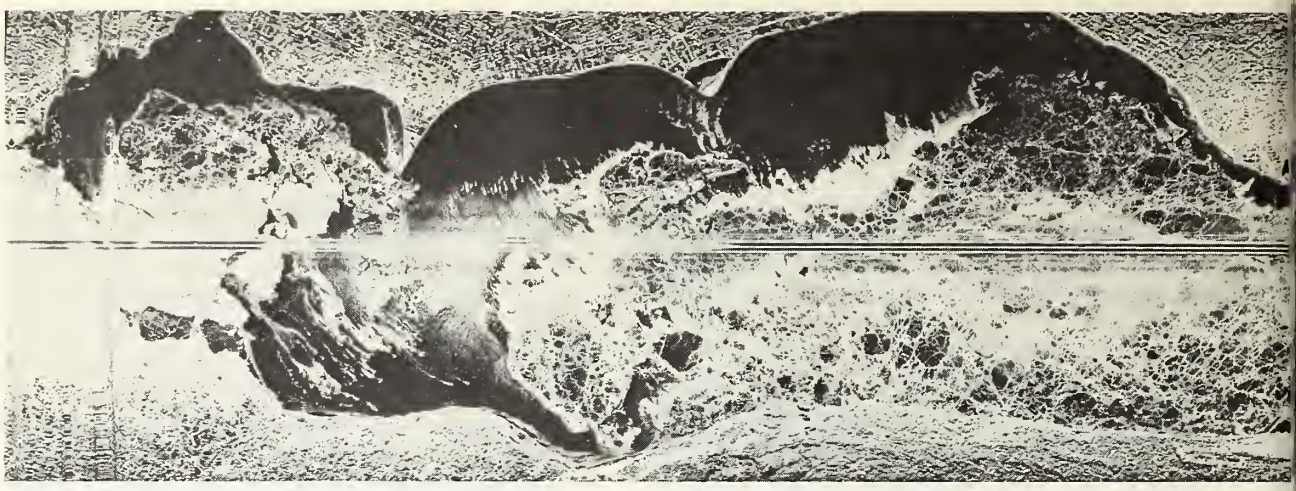


Figure 2.—Ice cover on Lake Erie Feb. 22, 1973, as recorded through cloud cover on Side-Looking Airborne Radar (SLAR) by NASA Lewis as part of a multiagency effort to extend the Great Lakes shipping season.

where man's activities have had significant—often drastic—impact on environmental quality. These waters, already seriously affected, face further environmental degradation without some form of management, based on adequate monitoring and prediction services in response to recent legislation to control ocean dumping, to minimize water pollution, and to manage the coastal zone (table 7).

Description

Prior to the recent legislation "Federal Water Pollution Control Act Amendments of 1972" (PL 92–500) and the "Marine Protection, Research, and Sanctuaries Act of 1972" (PL 92–532), these waters faced considerable potential degradation. Implementation of this legislation by criteria development and regulations and support through enforcement, research, and monitoring programs by many of the Federal environmental agencies will produce the prescribed environmental management system leading to reduction of pollution in the marine environment.

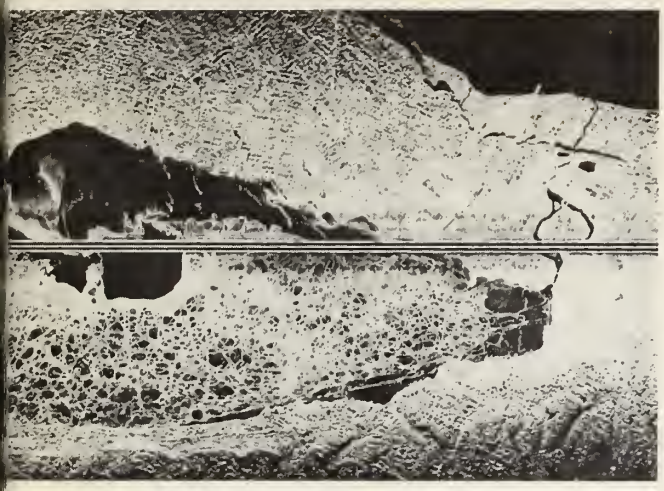
A continuing program for collecting new information, identifying research needs, and support of research and monitoring efforts of EPA and other agencies will be initiated on a small scale during FY 73 and expanded in the future as resources allow. There must be a continuing investigation of the effects of pollution on the marine environment to develop the techniques and knowledge necessary to adequately protect it.

The President of the United States under

Table 7.—Funding of Marine Environmental Prediction Service for water pollution assessment, by agency

[Thousands of dollars]

Agency	Operations		Research		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce	1,158	1,408	4,416	4,541	5,574	5,949
Defense		3,000	3,977	3,199	3,977	6,199
Transportation	644	836	63	63	707	899
AEC			63	63	63	63
EPA	6,323	6,724	4,431	4,833	10,754	11,557
NASA			300	239	300	239
Total	8,125	11,968	13,250	12,938	21,375	24,906



Reorganization Plan No. 3 delegated to the Environmental Protection Agency (EPA) the responsibility to obtain the maximum protection of the environment. During FY 74, EPA will maintain the basic strategy of:

1. Implementation of the Federal Water Pollution Control Act Amendment of 1972 (PL 92–500).
2. Implementation of the Marine Protection, Research, and Sanctuaries Act of 1972 (PL 92–532).
3. Provide strong support to State and local pollution control programs.
4. Obtain immediate improvement through emphasis on enforcement.

Programs having a bearing on Marine Environmental Prediction under these strategies initiated in FY 1973, to be expanded in future years as funds allow, include action to:

1. Equip and maintain a water quality surveillance system to monitor the quality of the navigable waters, ground waters, and the waters of the coastal zone and the oceans in cooperation with the States, their political subdivisions, and other Federal agencies.
2. Conduct comprehensive estuarine studies.
3. Conduct research for the prevention, control, and elimination of oil and hazardous substances pollution.
4. Conduct research with respect to the quality of the waters of the Great Lakes.
5. Establish a continuing program of regulation for ocean disposal under criteria which shall be developed to insure that the marine environment will not be degraded.

The National Oceanic and Atmospheric Administration and EPA participate jointly in many areas of marine environmental quality monitoring. The National Marine Fisheries Service monitors pesticide residues in marine organisms at 190 coastal and oceanic stations. This monitoring procedure is used to establish baselines and trends as well as avert problems in areas where pesticides are accumulating. The National Ocean Survey studies circulation in several coastal areas, measures tidal currents and tides in many estuaries and coastal locations, and collects data on the physical and chemical characteristics of the fresh water in the Great Lakes. The Environmental Research Laboratories of NOAA have several relevant projects underway: projects to predict the impact of marine mining operations and investigations to provide data helpful in describing advective and diffusive regimes that will be pertinent in determining the fate of various pollutants. NOAA's Marine Ecosystems Analysis (MESA) project is scheduling a full-scale field project in the New York Bight to describe in a systematic way the significant features of marine environmental interrelationships.

A part of the Geological Survey water quality program is carried on specifically in cooperation with EPA to provide background data on water pollution. In this activity USGS maintains about 55 stations on streams near the heads of estuaries. Samples taken at these stations are analyzed generally for trace metals, coliform and fecal coliform bacteria, pH, temperature, and ion concentration. Turbidity, nutrients, dissolved oxygen, and biochemical oxygen demands are also observed at a few sites. For example, determinations of pesticide concentration are made biannually at many stations in Puerto Rico.

Selected U.S. Coast Guard vessels and land stations, equipped with salinity-temperature-depth (STD) sensors and sampling devices, are used in a variety of in-house and cooperative programs for the analysis of properties of coastal waters.

In FY 1973 the Coast Guard expanded its monitoring activities begun during FY 1972 in support of the MAREP service for water pollution assessment. Highlights of Coast Guard activities in this area were procurement of airborne sensor systems capable of all-weather day/night detection of oil spills, establishment of mobile pollution monitoring teams to make periodic checks on selected harbor and estuarine areas, and continued engineering development of fixed-platform remote monitors. Further growth is expected during FY 1974.

In response to Executive Order 11057, a Navy-wide program has been established for prevention, control, and abatement of air and water pollution ashore and afloat as well as the development of methods for predicting and enhancing environmental quality. Whereas a majority of the present Navy programs are oriented toward developing and installing equipment to eliminate pollutants at their source, several programs are directly linked to environmental measurement and are being pursued both independently and in concert with other Federal agencies. An environmental data base program has been established to assess the extent to which the environment is affected by Navy ships, aircraft, and shore installations. Data acquired under this project will also be used to evaluate the effectiveness of pollution abatement efforts.

In early FY 1973 the Navy established the Ecology Spot Report on a trial basis. These reports will be initiated with the observation of pollution on the high seas and when any other unusual events in the categories of earth sciences, astrophysics, or biological science might be observed. The reports are forwarded to the Coast Guard, EPA, NOAA, and Smithsonian as well as Navy activities.

The National Oil and Hazardous Substances Pollution Contingency Plan has been developed in compliance with the Federal Water Pollution Control Act, as amended. The Plan includes all U.S. navigable waters, their tributaries, and adjoining shorelines. Coverage of the Plan includes inland rivers, the Great Lakes, coastal territorial waters, and the high seas where there exists a threat to U.S. waters, shoreface, or shelf bottom (fig. 3).

Objectives of the Plan are to minimize damage from oil and hazardous substance discharges and to contain, disperse, and remove them. The Plan also promotes the coordination and direction of Federal, State, and local response systems and encourages the development of local government and private capabilities to handle such pollution spills. Federal agen-

Figure 3.—Oil slick left by a sinking tanker 300 miles east of Norfolk, Va. Photographed by NOAA aircraft for EPA.

cies' responsibilities established by Statute, Executive Order, or Presidential Directive and which define the Federal response to a pollution spill are:

- The Council on Environmental Quality (CEQ) is responsible for preparation, publication, revision, and amendment of the Plan in accordance with Executive Order 11548. The CEQ will receive the advice of the National Response Team (NRT) and insure that disagreements among NRT members are settled expeditiously.
- The Department of Commerce supports the NRT, the Regional Response Team (RRT), and the On-Scene Coordinator (OSC) with respect to marine environmental data; living marine resources; current and predicted meteorologic, hydrologic, and oceanographic conditions for the high seas, coastal, and inland waters; design, construction, and operation of merchant ships; and maps and charts, including those for tides and currents of coastal and territorial waters and of the Great Lakes.
- The Department of Health, Education, and Welfare is responsible for providing expert advice and assistance relative to those spills or potentials for spill that constitute or may constitute a threat to Public health and safety.
- The Department of Defense, consistent with its operational requirements, may provide assistance in critical pollutant spills, in the maintenance of navigation channels, and in the salvage and removal of navigation obstructions.
- The Department of Interior provides expertise in oil drilling, production, handling, and pipeline transportation. Also, Interior has access to and supervision over continuously manned facilities which can be used for the command, control, and surveillance of spills from operations conducted under the Outer Continental Shelf Lands Act. Additionally, Interior will provide, through its Regional Coordinators, technical expertise to OSC and RRT with respect to land, fish and wildlife, and other resources for which it is responsible. The Department also administers American Samoa and the U.S. Trust Territory in the Pacific.
- The Department of Transportation provides expertise regarding all modes of movement for oil and hazardous substances. Through the Coast Guard, a Department representative serves as vice chairman of NRT. Transportation is also knowledgeable in the domestic and international fields of port safety and security, marine law enforcement, navigation, and in the construction, manning, and safety of vessels and marine facilities. Additionally,. the Coast Guard maintains continuously manned facilities that are capable of command, control, and surveillance for spills in U.S. navigable waters or on the high seas. The Coast Guard is responsible for the chairmanship of RRT for coastal regions and for the development, implementation, and revision of regional plans for those areas in which it is responsible for furnishing or providing for OSCs.

During FY 1973 the National Strike Force, a cadre of personnel trained and equipped to respond to discharges of oil and other hazardous polluting substances, was organized into three teams in Atlantic, Pacific, and Gulf locations. Each team is an operating unit of the Coast Guard with a commissioned officer in command.

- The Environmental Protection Agency (EPA) chairs the NRT. In this capacity EPA will assure that the National Oil and Hazardous Substances Pollution Contingency Plan is effectively and efficiently implemented with optimum coordination among Federal agencies and may recommend changes in the Plan to CEQ. The EPA is responsible for the chairmanship of RRT in inland waters and for the development, revisions, and implementation of regional plans for those areas in which it is responsible for furnishing or providing for OSCs. In coastal waters where the Department of Transportation is responsible for chairing RRT, EPA will guide and coordinate regarding pollutants control and protection of the environment. Through the Office of Water Programs, EPA will provide technical expertise to NRT and RRTs relative to environmental pollution control techniques, including assessment of damages and environmental restoration.
- The Department of Justice is to supply legal advice to deal with complicated judicial questions arising from spills and from Federal agency responses.
- The Department of State provides assistance and coordination whenever a pollution spill transects international boundaries or involves foreign flag vessels.

Plans for Improvement

The Navy intends to play a significant role in FY 1974 in prevention, control, and abatement of air and water pollution ashore and afloat as well as in developing methods for enhancement of environmental quality. Some of the environmental protection problems confronting the Navy can be solved by construction projects such as installation of incinerators and sewage treatment facilities or modification of existing facilities. In many instances, however, the solution requires research and development to comply with the requirements of new or expected legislation.

Because of the diversity of seagoing operations supported by extensive shore facilities, the Navy has

categorized its attack on pollution into the following six areas: (1) Ship waste, (2) oil pollution abatement, (3) ordnance pollution abatement, (4) aircraft pollution abatement, (5) pollution abatement ashore, and (6) establishment of an environmental protection data base. The area of particular relevance to MAREP is the data base effort. This project was undertaken by the Navy to gather data showing the effect on environment of naval ships, aircraft, and facilities. It is intended to uniformly assess the impact of abatement measures as well as other environmentally significant actions. The Navy plans to initiate its operational phase of collecting data on effluents at the end of FY 1973.

During FY 1973 the Coast Guard began utilizing surface-current measuring probes to monitor oil spills and predict their drift. This effort will continue into FY 1974 and will include both surface and air-deployed probes.

SPECIALIZED MAREP SERVICE FOR LIVING MARINE RESOURCES

Introduction

Federal responsibility for providing a MAREP service for living marine resources to those who utilize them or are responsible for their management and conservation rests with NOAA's National Marine Fisheries Service (NMFS). Primary responsibility for the Great Lakes rests with the Fish and Wildlife Service of the Department of the Interior. In addition the products and warnings of other MAREP services applying to fisheries interests are included in this category. This information, particularly important for protection of lives and property at sea, also helps fishermen select areas of concentration and where weather conditions, sea state, and temperature are favorable for operations. Agency allocations of funds for living marine resources services are indicated in table 8.

Description

Predictions in fisheries may be categorized as either tactical or strategic. Tactical predictions deal with day-to-day and week-to-week changes in locations of fish concentrations, particularly in response to environmental conditions. These predictions are principally valuable to fishermen and fishery scientists while they are working at sea. NWS is responsible for that portion of the tactical predictions containing the meteorological and physical oceanographic conditions. Tactical forecasts for fisheries are exemplified by Fishery Advisory Bulletins broadcast by radio daily to the albacore fleet in the eastern Pacific Ocean by the NMFS Southwest Fisheries Center at La Jolla, Calif.

Strategic predictions are designed to be valid for a longer term and deal with (1) abundances of year classes and populations of fishery species and (2) major changes in environmental conditions that influence species abundances and distributions. Abundance forecasts are based upon analyses of catch effort and age composition data from fisheries and survey cruises, from which estimates are made of the number of larval, juvenile, and adult fish and shellfish. These strategic predictions are of fundamental importance to management and conservation of fishery resources. They also provide a background for NMFS participation in environmental decisionmaking by water resources planning and development agencies.

Strategic predictions by NMFS, some in cooperation with international commissions and various States, are made on the abundances of shrimp in the Gulf of Mexico, of several groundfish species and menhaden off the U.S. east and gulf coasts, of red and pink salmon and halibut in the Pacific Northwest fisheries area, of sardines off Baja California, and of skipjack tuna in Hawaiian waters.

Information concerning sea surface temperature is of direct use to fisermen and fishery biologists and is

Table 8.—Funding of Marine Environmental Prediction for living marine resources, by agency

[Thousands of dollars]

Agency	Operations			Research			Total		
	FY 73	FY 74	Difference	FY 73	FY 74	Difference	FY 73	FY 74	Difference
Commerce	5,855	5,855		17,215	17,215		23,070	23,070	
Interior				325	325		325	325	
Transportation	734	867	+133				734	867	+133
NASA				453	257	−196	453	257	−196
Total	6,589	6,722	+133	17,993	17,797	−196	24,582	24,519	−63

provided to users routinely on both the Atlantic and Pacific coasts. Sea surface temperature charts of the eastern Pacific are compiled twice monthly from information supplied by the U.S. Navy, U.S. Coast Guard, and the fishing fleet. These charts, now in their ninth year of publication, are distributed to assist fishermen in selecting optimum fishing areas. The U.S. Coast Guard also conducts monthly flights over the Continental Shelf area off the Atlantic coast to record data on surface-swimming animals as well as sea surface temperatures. Charts of these data are prepared and mailed monthly to fishermen, various institutions, and other users.

To meet the needs for strategic resource predictions, NMFS initiated the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program. The overall objectives of MARMAP are to:

- Develop techniques for obtaining accurate measures of the abundance and geographic distribution of living marine resources available to the United States.
- Assess the productive capacity of these resources on a sustained yield basis and develop models for predicting future yields.
- Monitor seasonal and annual fluctuations in the distribution and abundance of various life stages of pelagic and demersal fishery resources and relate them to environmental factors and utilization by man.

To achieve these MARMAP objectives requires:

- Developing a national system for acquisition, compilation, analysis, and dissemination of information on the resource populations and their environment.
- Collecting and analyzing data from fisheries on catch effort, age composition, and migration of the stocks to produce stock assessments and fishery evaluations.
- Obtaining environmental data necessary to formulate models of large-scale relations between physical environmental factors and biological communities, with emphasis on distribution and abundance of the resource species.
- Conducting surveys of major biological communities of living marine resources in sufficient geographical and temporal detail for assessment and prediction purposes.

The MARMAP initiative involves three kinds of resource surveys—ichthyoplankton, groundfish, and pelagic fish—and a continuing analysis of the effects of harvesting on exploited populations. Information is obtained on catch effort, mortality, fecundity, growth, migration, etc., to monitor the conditions of utilized stocks. The best management decisions are made from clear demonstration of effects of fishing on the resource, the maximum amount of fishing that will sustain the stocks, and the loss or gain of resource production based on proposed management measures.

The surveys differ principally in sampling methods and data analysis techniques and provide independent assessments of resources whether fished or not. These surveys are performed aboard ships of the NOAA fleet, together with those of the Coast Guard, cooperating States, laboratories, and private organizations. Supplemental data will be obtained from buoys, satellites, and ships of opportunity.

In FY 1973 an initial MARMAP survey for ichthyoplankton was conducted in the waters from Cape Cod to the Caribbean. The principal objectives of the survey were twofold: (1) to test the MARMAP data acquisition, reduction, and analysis system during a multiship operation, and (2) determine the effects of the Gulf Stream system on the distribution of fish eggs and larvae of important gamefish (tuna, marlin, sailfish, bluefish, jacks) and commercial species (herring, cod, flounder, mackerel, and others). Participating vessels included the *ALBATROSS IV* from the Northeast Fisheries Center and the *DELAWARE II* from the Mid-Atlantic Coastal Fisheries Center. In addition to the expected plankton and larval fishes, significant amounts of plastic and tar contaminants were collected in nets towed at the surface. Concentrations of plastics were found in the waters of the Mid-Atlantic Bight from Long Island to Cape Hatteras. The tar balls occurred most frequently in offshore waters; greatest concentrations were in the western boundary of the Sargasso Sea about 200 miles east of the Bahamas. The accompanying charts show the MARMAP survey-vessel transects and the areas from which tar and plastics were collected.

Figures 4 and 5 show tar and plastic contamination of the Atlantic encountered during the MARMAP resource survey in FY 1973.

Plans for Improvement

Activities of MARMAP in FY 1974 with existing funds include:

- Bringing together and integrating fisheries data and analyses from all relevant sources. Analytical work is detailed under research in physical oceanography in the section "Research Relevant to Marine Environmental Prediction."
- Acquiring equipment for environmental processing and analysis groups.
- Entering into cooperative contracts with Federal, State, and private institutions for processing, analysis, and production of formatted output of living resources and environmental data obtained dur-

ing MARMAP operations.

- Conducting tests to demonstrate the feasibility of various types of sampling gear to provide Survey II capability, including acceptance or rejection of multiple-gear type for development.
- Conducting tests to demonstrate the feasibility of various sensors to provide the means of remote underwater assessment of benthic and demersal sport and comercial species (Surveys II & III), including acceptance or rejection of some sensors for full-scale development.
- Continuing resource and environment survey operations in cooperation with other countries, principally of the northeast and southwest coasts of the United States.
- Conducting tests to demonstrate the feasibility of various direct-sampling and remote-sampling methods for surveys of pelagic fish (Survey III).

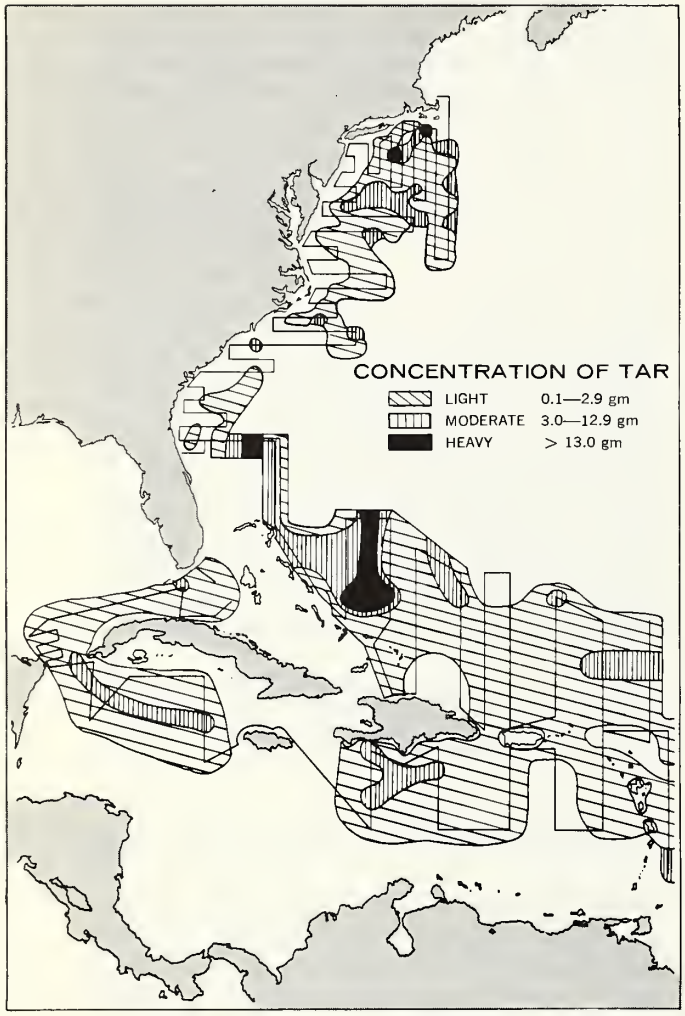


Figure 4.—Concentrations of tar found during fiscal year 1973 MARMAP resource surveys.

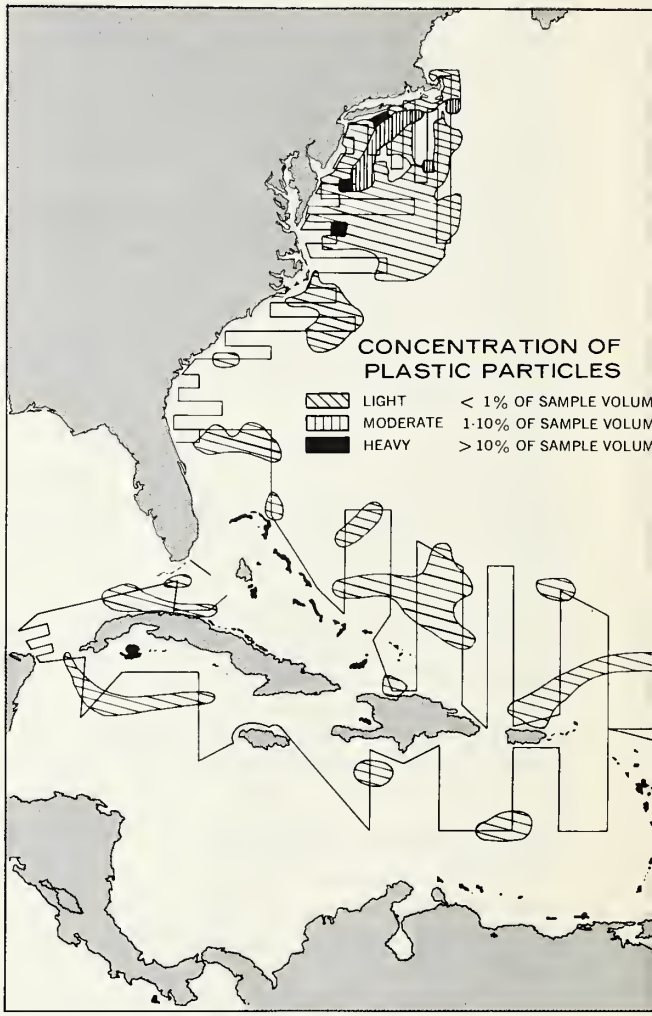


Figure 5.—Concentrations of plastic particles found during fiscal year 1973 MARMAP resource surveys.

Activities by the Bureau of Sport Fisheries and Wildlife of the Department of the Interior are described in "Research Relevant to Marine Environmental Prediction" under research in biological oceanography.

SPECIALIZED MAREP SERVICE FOR OCEAN ENGINEERING

The Navy's ocean engineering program includes such efforts as site surveying for ocean bottom construction; research and development in areas like concrete for underwater construction and manned and unmanned submersible design, construction, and operation; design and development of oceanographic data collection instruments; design, development, and installation of near-shore and underwater facilities.

MAREP services are needed to provide forecasts of environmental factors that affect ocean engineering operations. These environmental factors include wind, wave, current, tide, biological condition, bottom property, and littoral drift in the coastal zone and sea, swell, wind, current, water clarity, bottom character, chemical composition, and biological conditions and activity outside the coastal zone. Most of the general services provided in support of ocean engineering are covered under "Specialized MAREP Service for National Security." In addition, requests to support highly specialized operating problems and hardware are frequently responded to on a one-time basis by NAVOCEANO, by the Navy Coastal Systems Laboratory, or by the Naval Weather Service Command.

SPECIALIZED MAREP SERVICE FOR NATIONAL SECURITY

Defense activities involving a need for specialized marine environmental knowledge include search, rescue, and salvage; antisubmarine warfare (ASW); amphibious operations; mine warfare; polar operations; and ocean and coastal engineering. In addition, routine fleet operations require a large volume of marine information and predictions not otherwise obtainable in the Basic MAREP Service.

Examples of marine environmental parameters, in addition to weather conditions, predicted for special defense matters include sea, surf, and swell; sea surface temperature; thermocline depth; subsurface thermal structure; subsurface current vectors; special factors related to underwater sound; sea ice cover; optimum conditions for ship routing; and biological factors such as false targets, deep scattering layer, and organisms producing reverberation.

Much of the Defense effort in MAREP is applied in support of various ASW systems. This support is essential because the propagation of underwater sound is central to most aspects of ASW, and the behavior of sound in sea water is strongly influenced by marine environmental factors. With more understanding of the ocean's complexity and variability, it is evident that the controlling environmental conditions must be monitored and projected into the future on a broad basis for ASW.

The MAREP service for national security is the only Specialized MAREP Service containing all elements of the basic MAREP system: Data acquisition platforms, data collection and communications, data processing functions, and product dissemination media. In some cases the MAREP service for national security of the Department of Defense complements and provides essential support for the Basic MAREP Service. As an example, hundreds of ship observations and scores of aircraft observations are made available to the Basic MAREP Service on a daily basis. Most Defense MAREP activities, however, support unique defense needs of the Nation. In meeting these needs, DOD has developed programs in the following MAREP areas:

Ice forecasting
Hurricane and typhoon reconnaissance
Ship routing
Surf forecasting
Typhoon and hurricane evasion
Sea surface temperature fields
Sea conditions (wave, height)
Meteorological forecasts over worldwide ocean areas
Subsurface ocean water properties
Acoustic conditions
Biological effects on acoustics
Ocean floor characteristics and beach conditions

The U.S. Navy operates a full-service, wide-ranged Federal MAREP system for defense needs. The core of this system is the Fleet Numerical Weather Central (FNWC) located in Monterey, Calif. Products from the main computer processing component of FNWC are disseminated by the Naval Environmental Data Network (NEDN) through interconnected digital computers and on-line communications equipment (fig. 6). The FNWC processes, disseminates, and displays meteorological and oceanographic analyses and forecasts on a hemispheric basis to meet Defense needs. Through FNWC, real-time products are continually updated and tailored to meet fleet and other requirements of Defense. The FNWC products (table 9) are distributed through NEDN to Fleet Weather Centrals and Facilities strategically located around the world. FNWC is the master center for collecting and processing worldwide data inputs of meteorological and oceanographic parameters. Re-

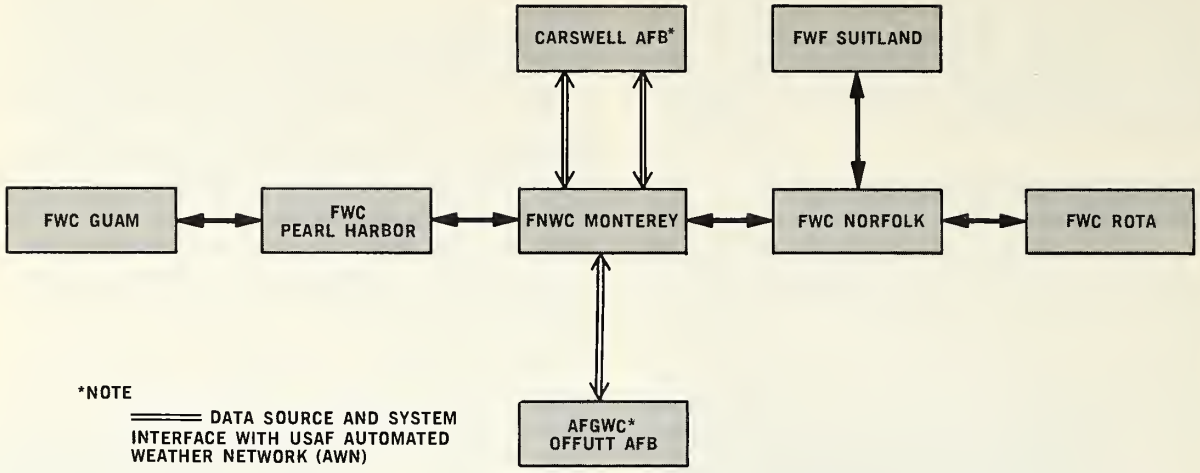


Figure 6.—Naval Environmental Data Network (high-speed 2,400 baud circuitry).

sponsibilities for providing fleet support throughout the oceanic regions of the world are shared by Fleet Weather Centrals at Guam, Pearl Harbor, Norfolk, and Rota (Spain). Computers at these Centrals receive processed data from FNWC and write environmental support products tailored to naval forces at sea and ashore. The Centrals use the broad-scale products from FNWC and, where available and applicable, the products from the National Meteorological Center (NMC) of NOAA to prepare detailed analyses, forecasts, and warnings for their areas of responsibility. The Fleet Weather Central products are disseminated to naval operating forces, smaller naval environmental units, and other components of the Department of Defense through the Naval Communications System.

Typical FNWC fleet support services are:

Numerical weather and oceanographic analysis and forecast charts for fleet facsimile broadcast.

Edited data summaries for channel 8 of the fleet multi-channel broadcast.

Ballistic wind and density forecasts for strategic support.

Sound-propagation loss forecasts for ASW operations.

Wave forecasts for replenishment planning, long-haul OTSR, and high-seas warnings.

Radiological fallout forecasts for naval operating areas.

Drift computations for vessels and aircraft in distress.

Swell forecasts for surf prediction.

Tide predictions for amphibious and logistic operations and storm-surge warnings.

More than 60 weather offices at shore stations and aboard larger ships provide MAREP services for naval operations. The focus for environmental support is at the operating level. The primary objective of this support is meteorological and oceanographic information and advice to operational commanders. Briefings generally are conducted in person, but they may also be provided by telephone or closed-circuit television.

Oceanographic observations are transmitted to FNWC for hemispheric analyses. Data are also forwarded to NAVOCEANO, San Diego State College, Woods Hole Oceanographic Institution, U.S. Coast Guard, NMFS and National Oceanographic Data Center (NODC) of NOAA, Canadian Forces, British Royal Navy, and other countries for forecasting purposes, research support, and archiving. The FNWC performs hemispheric-scale oceanographic analysis every 12 hours, using a complex forecasting model based on theoretical considerations, climatology, and empirical equations. These analyses and forecasts are made available to Naval Weather Service Command (NWSC) activities that are engaged in immediate fleet support. Oceanographic products are distributed to users by various communication systems, such as fleet broadcasts, radio teletypewriter, facsimile, digital data links, and nonelectronic means.

The NAVOCEANO prepares experimental oceanographic forecasts in support of complex or specialized operations where an operational technique has not been developed. These forecasts, tailored to specific applications, include information concerning waves, currents, thermal structure, and ice. In addition to specialized forecasting activities, NAVOCEANO prepares oceanographic charts, publications, atlases, and related materials required by fleet and Defense planners.

Table 9.—Marine Environmental Prediction products of the Naval Weather Service Command

Title	Products	Cycle
General weather forecast	Synoptic analysis/forecast.	
Waves—direction, period, and height		12 hourly.
Swell—direction, period, and height		Do.
Combined sea—direction, period, and height		Do.
Surface currents		Do.
Surface weather factors (e.g., wind, temperature, fog, and precipitation)		Do.
Cloud coverage		Do.
Oceanic fronts		Do.
Oceanic dispersion		As requested.
Air-ocean heat exchange		Do.
Gale, hurricane, and storm warnings		12 hourly.
Optimum Track Ship Routing (OTSR) and weather advisories (WEAX)	Individual forecast	As requested.
Search and rescue drift forecast	....do	Do.
Marine Climatic Atlas	Book (series)	As available.
Ocean-Area Observations	....do	Do.
Sea surface temperature	Synoptic analysis	12 hourly.
Mixed layer depth	Synoptic analysis/forecast	Daily.
Below layer gradient	....do	Do.
Upper sound channels	....do	On request.
Probability of transients (thermal gradients)	....do	Do.
Bathythermograph and sound-velocity profiles	....do	Do.
Acoustic Sensor Range Prediction (ASRAP) system	Individual forecast	Daily.
Ship-Helicopter Acoustic Range Prediction System (SHARPS)	....do	Do.
Detailed propagation loss	....do	On request.
ASW Oceanographic Environmental Service (NAVAIR 50-IG-24)	Booklet	As available.
Oceanographic Outlooks	Booklet (series)	Quarterly.
Southern Ice Limit—Eastern Arctic (AXAC1)	Synoptic analysis/forecast	Weekly.
Southern Ice Limit—Western Arctic (AXAC2)	....do	Do.
Short-range ice forecast	Individual forecast	On request.
Northern ice limit—Antarctic	Synoptic analysis	Weekly (mid-Oct. to mid-Feb.).

Research Relevant to Marine Environmental Prediction

INTRODUCTION

Federally supported research and development that will contribute to future improvements in MAREP services are presented in this chapter.

Federal funds spent in FY 1973 and planned for expenditure in FY 1974 in various MAREP research programs are summarized in table 1 in the section "Summary of Fiscal Data." Federal funds allocated for research in support of MAREP functions in FY 1973–74 are shown in table 10.

Major research by Federal agencies to improve MAREP services is described in the following paragraphs, and discussed under three categories: Research for the improvement of functions which constitute a MAREP system; research necessary for the understanding of the basic marine processes; and research in geographic areas of special interest.

IMPROVEMENT OF MAREP FUNCTIONS

Research programs directed specifically toward improvement of the functions necessary for MAREP are described under "Data Acquisition" and "Information Processing and Dissemination."

Data Acquisition

The NOAA Data Buoy Office (NDBO), funded at $8,500,000 for FY 74, is one of the largest single research and development programs in support of MAREP. NDBO, established originally under the direction of the U.S. Coast Guard, is now a part of NOAA's Basic Marine Observation program. The office has a three-fold role: As a center for environmental data buoy technology it conducts the applied research and development necessary to define and upgrade reliable buoy components and systems; con-

Table 10.—Funding of research relevant to Marine Environmental Prediction, by function

[Thousands of dollars]

Agency	Understanding basic processes		Data acquisition		Communications		Data processing		Information dissemination		Agency support of research		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce	35,933	36,140	11,786	14,999			2,162	2,162	440	440			50,321	53,741
Defense	7,781	8,848	8,033	7,705	587	612	854	1,091	1,633	1,777	100	100	18,988	20,133
Interior	[1]1,731	[1]1,758									156	159	1,887	1,917
Transportation	1,475	1,584	1,844	1,980							368	396	3,687	3,960
AEC	[1]4,846	[1]5,523											4,846	5,523
EPA	[1]4,431	[1]4,833											4,431	4,833
NASA			4,001	2,875									4,001	2,875
NSF	[1]16,575	[1]15,337											16,575	15,337
Smithsonian	[1]1,757	[1]1,757											1,757	1,757
Total	74,529	75,780	25,664	27,559	587	612	3,016	3,253	2,073	2,217	624	655	106,493	110,077

[1] Other functions included in this amount.

ducts the test and evaluation necessary to assess present and future data buoy systems; and serves as a national and international source of buoy technology information.

Additionally, the office functions as a center of environmental data buoy applications. In this capacity it provides or arranges for procurement, emplacement, and maintenance of data buoy systems in support of scientific and operational programs, and advises on environmental data buoys and buoy system applications.

The National Oceanographic Instrumentation Center (NOIC) of National Ocean Survey (NOS) provides for periodic calibration of instruments and serves as a focal point for information on oceanographic instrumentation technology.

The National Marine Fisheries Service (NMFS) is developing specialized equipment in support of MARMAP data acquisition: (1) The Remote Underwater Fish Assessment System (RUFAS), an instrument towed from aboard ship to detect subsurface fish and shellfish concentrations; (2) remote sensors for use on ships, aircraft, and satellites to detect concentrations of fish and shellfish; and (3) an undulating, continuous plankton recorder with associated environmental sensors and data recording systems.

RUFAS II is designed to improve the detection range and operational depth of the present RUFAS I, and tests are planned for other hydroacoustic systems for assessing fish stocks. The combination of RUFAS II and advanced systems will provide a capability to assess midwater and bottom-dwelling fish stocks by remote sensing.

At the fishery centers of NMFS numerous technology development projects are being carried out to advance data acquisition methods in the MARMAP surveys.

Other research and development projects supported by NOAA to improve MAREP data acquisition include the development of a low-cost drifting buoy location system, initiation of studies to determine wave characteristics from high-frequency backscattering, continued tsunami research, and improved instrumentation.

In data acquisition, the U.S. Navy plans to develop a modularized system for collecting salinity, temperature, bathymetry, and subbottom profiles and has initiated at its Naval Research Laboratory (NRL) in Washington a new effort to use remote-sensing techniques for military applications. This involves the use of aircraft or satellite microwave, infrared, and radar sensors to measure sea surface temperature, salinity, sea state, transparency, nutrients, radioisotopes, trace elements, currents, internal waves, and air-sea interactions. Automated meteorological sensors are being developed for shipboard and aircraft use.

Increased operational requirements in the Arctic have prompted the U.S. Navy to continue an ice surveillance program to collect data on the distribution of various ice features and conditions. Project BIRDSEYE uses airborne visual and instrument techniques to provide ice observations. Two of the remote sensors in use are infrared scanners and laser altimeters. The infrared scanner provides strip maps of the ice surface, permitting the delineation of various stages of ice development and often providing needed information on ice thickness. The laser altimeter permits accurate profiling of the ice surface, providing data on the frequency and size of ice features such as ice ridges and water openings. Recent experiments with Side-Looking Airborne Radar (SLAR) systems, which provide image maps with good surface feature resolution, indicate a high potential for remote sensors.

The Spacecraft Oceanography (SPOC) Program of NOAA contributes to improvement of MAREP services. Relevant research projects include experiments involving acquisition and analysis of remote-sensor and correlative-surface data for sea surface temperature, ocean color, sea ice, sea roughness, near-surface wind conditions, coastal and ocean currents, sediment tracing, and shallow underwater features.

NASA funds research projects which will advance the assessment and prediction of living marine resources through development of capabilities for data acquisition from space. These research projects involve application of remote-sensing techniques (including low-light-level television, graphic imagery, spectrophotometry and spectroradiometry, and microwave radiometry) for the observation of biological and physical phenomena, such as chlorophyll concentration, bioluminescence, fluorescence from fish scales and oil slicks, water color, upwelling surface temperature, and other indicators of surface currents. NASA also supports projects related to improvements in the Specialized MAREP Service for Water Pollution Assessment by emphasizing remote sensing of river effluents, water quality, and sediment transport. From the successful launch of NASA's Earth Resources Technology Satellite (ERTS 1) on July 23, 1972, multispectral imagery of the coastal zones was obtained with a ground resolution of 70 meters. This spacecraft-derived imagery has been found valuable in providing useful data on coastal processes and oceanic and estuarine phenomena. In FY 1974, NASA will continue research on remote sensing, using NASA, Navy, and NOAA aircraft (fig. 7) and ground truth observations from ships. Data analysis

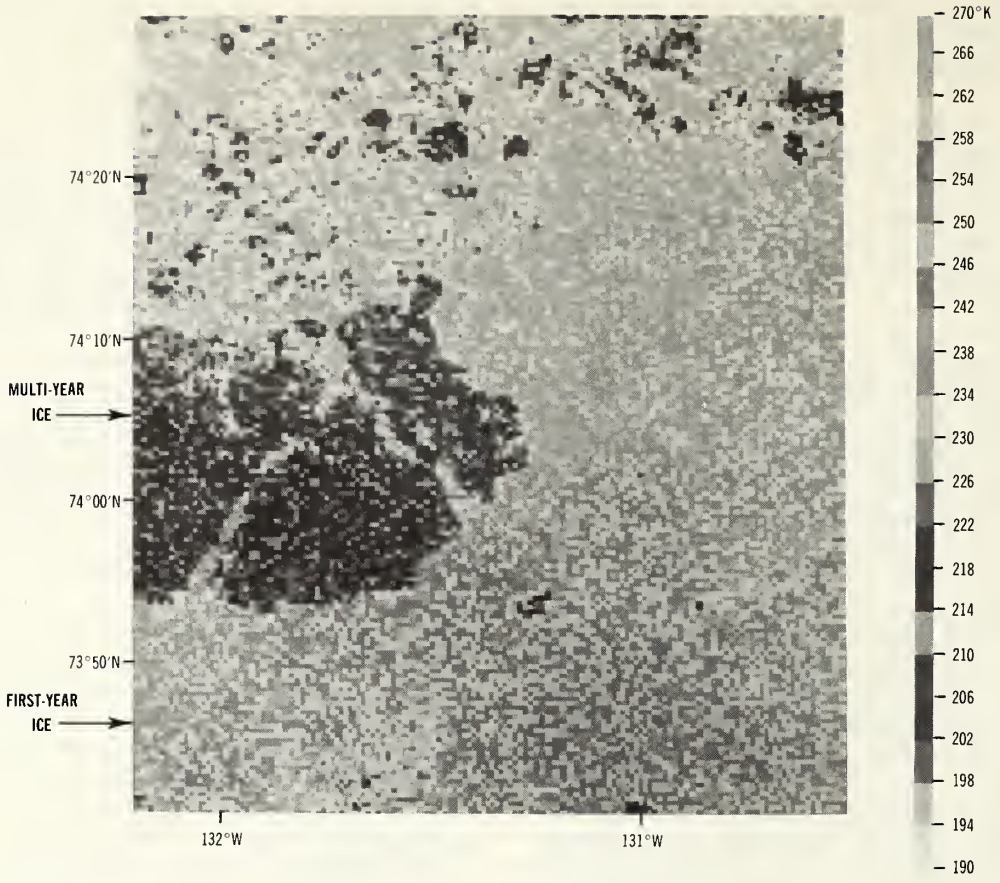


Figure 7.—Passive microwave image of Arctic sea ice (λ = 1.55 cm). (Taken by NASA CV–990 aircraft, March 16, 1971; cloudy day.)

techniques for information from the ERTS 1, SKYLAB, and Earth Orbiting Satellite (EOS) spacecraft will also be broadened.

An expanded NOAA/Environmental Research Laboratory (ERL) program in satellite oceanography will include analysis of data from ERTS 1, GEOS 3, and SKYLAB; ground-truth data acquisition for GEOS 3; assessment of the usefulness of altimeter and scatterometer data to the study of surface currents, wind waves, and tides; and studies of data from ERTS 1 on ocean color and sea surface temperatures.

The Coast Guard has pioneered in the use of SLAR in Arctic regions. Tests began with iceberg detection, identification, and tracking experiments for the International Ice Patrol. In 1973 the Coast Guard is refining these techniques of iceberg reconnaissance and consolidating them in an International Ice Patrol SLAR Manual.

In connection with its research program on explosion-generated water waves, the AEC is developing sensor, recording, and readout systems to measure and to document such waves.

The Environmental Protection Agency (EPA) has contracted for studies on specifications of an oil spill surveillance system that involves the real-time detection, alarm monitoring, and recording of oil spills and is contracting for marine environmental research to gain knowledge for processing ocean dumping permits. EPA and NOAA are cooperating to ascertain the necessary information for determining criteria for issuing ocean dumping permits.

Information Processing and Dissemination

Within National Weather Service (NWS) of NOAA, a program is underway for the development of automated techniques to produce forecasts of the marine environment in open oceanic areas, coastal areas, and the Great Lakes.

Work has continued on the development of an im-

proved method of wind forecasting for application to wave forecasting over oceanic areas. For the Great Lakes, a wave climatology was compiled. In coastal areas the numerical model for the Special Program to List Amplitudes of Surges from Hurricanes (SPLASH) has been developed for forecasting the hurricane storm surges along the U.S. gulf and east coasts: SPLASH is in experimental use at the National Hurricane Center (NHC). Equations have been derived for forecasting extratropical storm surges at 10 east coast cities.

A wave-forecasting technique for the Great Lakes will be developed and implemented. The hurricane storm-surge forecasting model at NHC will be further improved. Contract studies of a breaker-forecasting technique and investigation of hazardous-wave conditions over bars at the Columbia River entrance will be completed. In FY 1974, efforts will continue to improve those techniques developed earlier. In addition, the scope of techniques development will be expanded to include sea surface temperature, vertical temperature structure, and ice forecasting.

Support at a somewhat reduced level is expected for analysis of data from the International Field Year of the Great Lakes (IFYGL), and support will continue at approximately the FY 1973 level for studies of mixing and diffusion processes and for theoretical and numerical modeling. Additional numerical modeling and analysis will be done by the IFYGL Staff.

Fundamental studies of ocean dynamics and description of the chemical processes are funded by NSF through the Oceanographic Section of the Division of Environmental Sciences (DES). A goal for FY 1974 is to develop insights into the processes involved in water movements on the Continental Shelf. Several oceanographic investigations are also planned for the GARP Atlantic Tropical Experiment (GATE).

Both the Oceanography and Atmospheric Sciences Sections in DES fund individual studies of a fundamental nature. Many of these individual projects deal with microscale problems including transport of various materials across the air-sea interface. The Global Atmospheric Research Program in DES also funds individual research concerned with the global climatic implications of air-sea interaction. Large integrated projects with air-sea interaction are also important in GARP and some International Decade of Ocean Exploration (IDOE) projects.

The major programs in environmental forecasting sponsored by IDOE, NSF, are cooperative with other Federal agencies, principally ONR and NOAA. In some cases, they involve foreign laboratories and scientists. Two major programs now underway are the North Pacific Experiment (NORPAX) and the Mid-Ocean Dynamics Experiment (MODE). The objective of NORPAX is to provide in the North Pacific Ocean a scientific basis for improving long-range environmental forecasting. In FY 1974 the first data station array should be completed. Equipment will be selected for study of large-scale air-sea interaction in order to improve our understanding of the influence of the North Pacific Ocean anomalies on weather patterns over North America. The objective of MODE is to understand medium-scale dynamic processes and their roles in ocean circulation and global climates. The MODE experiment will take place between the U.S. and Bermuda as indicated in figure 8. The first operational phase of MODE commenced in FY 1973. Upon its completion in FY 1974, the major analytical studies of MODE data will be initiated.

UNDERSTANDING BASIC MARINE PROCESSES

Research is necessary for understanding basic marine processes and for improving and expanding MAREP services. A summary of the base programs is included here with emphasis on major program changes. Some multiyear Federal research of little change from that reported in the *FY 1973 Federal Plan for Marine Environmental Prediction* is not included.

Physical Processes

Understanding physical processes in the ocean and marine atmosphere is essential to MAREP. The Federal effort in this area is in four major categories: Large-scale research programs; structure and motion of the ocean; remote sensing; and coastal processes. These categories are not mutually exclusive, but have been selected because of their use in the Federal agency program structure.

Six large-scale oceanic research programs (discussed below) support MAREP and are in different stages of progress, i.e., planning, field operations, data analysis, etc. For the most part, each program involves two or more Federal agencies.

- NORPAX (North Pacific Experiment) is an NSF-Navy sponsored program to investigate large-scale air-sea interactions in the North Pacific. It is expected to last almost 10 years and is intended to describe the effects of ocean anomalies on global atmospheric circulation and the atmosphere's effect on the Pacific Ocean thermal and circulation structure.

- GATE (GARP Atlantic Tropical Experiment) is a multiagency international experiment to investigate the generation and structure of tropical disturb-

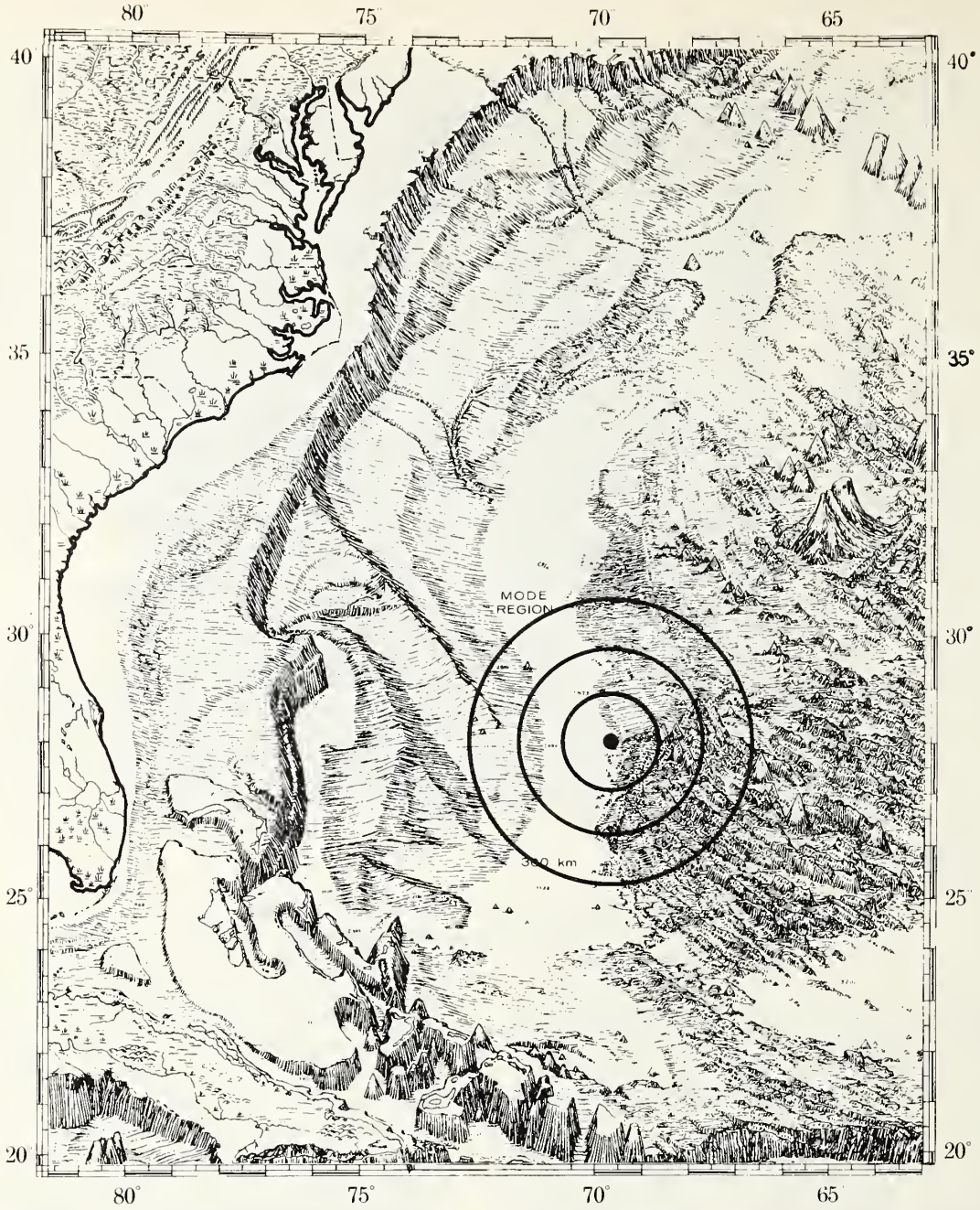


Figure 8.—The MODE region superimposed on a physiographic diagram of the North Atlantic Ocean. The region within 200 km from the center of the array will contain 20 instrumented moorings and 20 drifting floats. The British will conduct a special intense survey in the region within 100 km from the center.

ances and the Atlantic equatorial current system. DOC (NOAA) has been assigned U.S. lead agency; other participants include DOT, AEC, NASA, DOD, and NSF. Field operations are scheduled for summer 1974.

• MODE (Mid-Ocean Dynamics Experiment) is an NSF-sponsored program designed to obtain a better understanding of middle-scale dynamic processes such as geostrophic eddies and to elucidate their role in ocean circulation and in the global climate. Participation includes various university institutions and Federal laboratories funded by NSF as well as the Navy.

• AIDJEX: The objective of AIDJEX (Arctic Ice

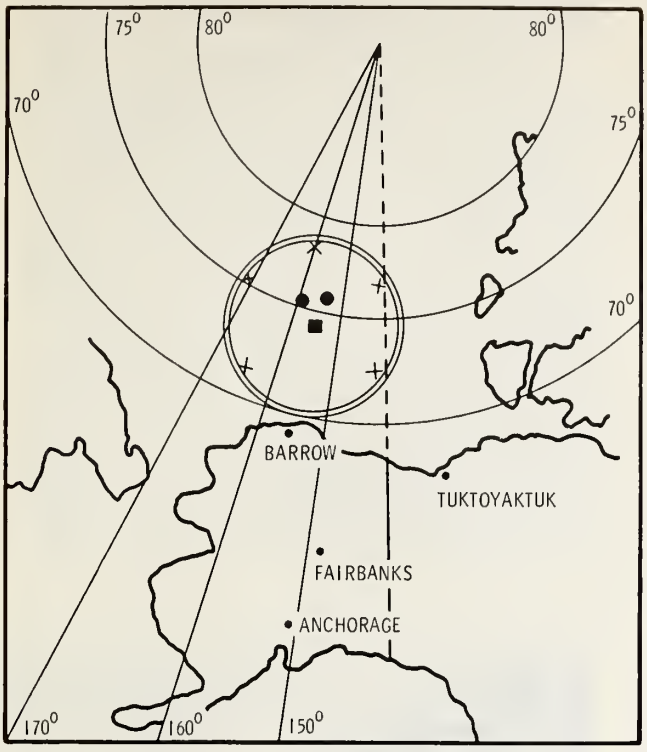


Figure 9.—1972 AIDJEX array.

Dynamics Joint Experiment) (fig. 9) is to study the larger scale response of sea ice to its environment in order to understand the interaction between ice cover and the global environment and to solve problems like the passage of ships in ice-covered seas. The main experiment is to consist of ice deformation studies based upon environmental measurements from four stations forming a 100 km square enclosing a central station. An array of unmanned buoys will be deployed in a 400-km grid outside of the square. Ranging targets will be placed about the central station, whereas tracking targets will be placed across shear zones. Extensive ground observations will be supplemented by remote sensing. Pilot studies of AIDJEX are underway with the main experiment planned for 1975. Simultaneously with the evolution of AIDJEX, U.S.S.R. has been developing a Polar Experiment (POLEX) which has similar but wider objectives, particularly with respect to the role of the polar regions in large-scale global processes. Coordination of AIDJEX with the first (Arctic) phase of POLEX as part of GARP is underway.

• BOMEX (Barbados Oceanographic and Meteorological Experiment) was an air-sea interaction experiment designed to investigate tropical circulation and the turbulent boundary layer. The lead was assigned to DOC (NOAA) with participation by almost all ICMAREP agencies during the field operations in 1969. Data analysis will be completed during FY 1973–74.

• MARMAP (Marine Resources Monitoring, Assessment and Prediction) is a NOAA program directed toward understanding bioenvironmental relations for living marine resources of importance to the Nation. Physical processes being investigated in MARMAP are changes in location and properties of water masses; location, strength, and divergence of currents and surface gyres; and wind stress transport as prime force causing upwelling.

Most agencies concerned with MAREP have programs relating to understanding the structure and motion of the oceanic environment. The Navy program is directed at oceanic effects on naval operations. For example, density anomalies influence long-range acoustical surveillance systems and thereby affect antisubmarine warfare and surface and subsurface motions affect safe operations of submarines and ships. NOAA programs in basic research on the structure and motion of the ocean are carried out by the Environmental Research Laboratories. Research is directed at increased understanding of physical, chemical, and dynamic properties and processes of the Atlantic Ocean, Caribbean Sea, and adjoining estuaries; at sea-air interaction and at the understanding of significant features in Pacific Ocean dynamics, including near-surface circulation in response to time-dependent wind stress.

DOT (Coast Guard) programs related to understanding the structure and motion of the ocean are directed toward support of the International Ice Patrol and Search and Rescue (SAR) missions. These efforts include studies on water-mass exchange and on currents affecting the presence and distribution of icebergs and sea ice in Baffin Bay and in the Grand Banks Area. Additional Coast Guard research is directed at responses of boat hulls, rafts, and life-saving devices to wind, waves, and currents.

A major effort incorporating data from many of these Federal research programs on structure and motion of the oceans is by NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) GFDL is developing a comprehensive theory and model for the total ocean circulation.

Several components within NOAA are involved in remote sensing programs which contribute to MAREP. The Spacecraft Oceanography (SPOC) Group and the Environmental Sciences Group (ESG) of the National Environmental Satellite Service (NESS) conduct in-house and outside research in

several areas of marine remote sensing. The SPOC Group works with NASA to develop and test new sensors and data processing and analysis techniques for sea ice, ocean color, ocean dynamics, and coastal marine measurements and observations. The ESG Group also conducts outside research but emphasizes in-house display, analysis, and interpretation of existing satellite data. The Earth Resources Technology Satellite (ERTS 1) multiband imagery is being evaluated for coastal oceanography, hydrology, and sea ice applications. NESS is involved in research to utilize the Scanning Radiometer (SR) and the Very High Resolution Radiometer (VHRR) data from the NOAA 2 satellite for global sea surface temperature mapping and for charting of thermal features of the oceans. NESS has supported academic, industrial, and Government marine science and engineering. Special efforts are being made to shift the emphasis of research in remote sensing toward applications of marine remote sensors to existing NOAA programs such as the Marine Ecosystem Analysis (MESA) program and the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program.

The National Marine Fisheries Service (NMFS) of NOAA maintains a remote sensing program in cooperation with NASA at the Mississippi Test Facility (MTF). In-house and outside marine remote sensing research is supported for fisheries applications.

The Atlantic Oceanographic and Meteorological Laboratory (AOML) is the principal focal point for applications of remote sensing to ocean dynamics (sea roughness, sea level, sea slopes, and marine geodesy). AOML is involved in ERTS and SKYLAB data analysis for ocean dynamics and ocean color applications.

The Federal research program related to MAREP in tsunami runup and wave shoaling has the participation of NOAA and AEC. NOAA is investigating the generation, propagation, and runup mechanisms of tsunamis, including the open ocean measurements of tsunamis. To complement this program, AEC is developing the capability to document, evaluate, and understand explosion-generated water waves resulting from nuclear detonations at or near the surface of the ocean. This effort includes theoretical studies on shoaling, phenomenology of such waves, and investigations required to predict and document the effects of a water wave resulting from seismic activity caused by nuclear explosion.

Biological and Chemical Processes

Three basic Federal thrusts in biological and chemical processes relating to MAREP services are underway in DOD, DOT, DOC, NSF, AEC and, the Smithsonian Institution. They can be described as basic biological investigations, ecosystem studies, and pollution and baseline studies.

Basic biological investigations related to MAREP are conducted through the ONR oceanic biology program with emphasis on understanding the role of biological processes in naval operations. The primary objectives are to enhance the Navy's capability to predict, evade, or control those biological systems alien to military interests and to adopt the desirable biological attributes. Complementary biological investigations and research are also conducted through various elements of the Smithsonian Institution. As examples, the National Museum of Natural History maintains the largest collection of biological specimens available for scientific research, and the Smithsonian Oceanographic Sorting Center (fig. 10) provides basic sorting of organisms, community analyses, and specimen and data mangement for the research community. NSF supports basic biological studies

Figure 10.—A portion of the Smithsonian Oceanographic Sorting Center specimen storage area.

leading to an improved understanding of marine organisms and their relation to nutrition. This program aims for comprehensive systems analysis and computer-assisted modeling by 1975. AEC and NMFS are cooperating to investigate the effects of thermal effluents on the biota. NMFS is also conducting a variety of research toward understanding the basic requirements of species in commercial and recreation fisheries and identifying the impact of overfishing on the stock.

A large part of the biological research in support of MAREP is being conducted in the area of ecosystems and ecological understanding. This work is directed toward the ability to predict and assess changes in various parts of the marine environment both from manmade and natural causes. One good example of this type of large-scale multidisciplinary research is the cooperative ecological study of the Chesapeake Bay, supported by the Corps of Engineers, NSF, Smithsonian Institution, and various universities. The research involves an extensive review of the social, legal, and environmental conditions of the Bay so that a plan can be developed for proper resource management. NOAA is also conducting a variety of ecological studies primarily through NMFS and the Marine Ecosystem Analysis (MESA) Project. These studies are to determine the effects of natural and manmade changes in the estuarine and marine environment, including the amount and rate of accumulation of stable pollutants, e.g., polychlorobiphenyls, pesticides, and heavy metals. Three major areas will be studied over the next few years. The MESA project will concentrate heavily on the New York Bight, where for years there has been massive dumping of sludge, chemical wastes, and munitions. The NMFS studies are concentrating on the Gulf of Mexico with emphasis on the impact of water resources demands, i.e., irrigation, dredging, and fill operations. Studies in the Pacific Northwest and TAPS area will focus on impacts of oil spillage, mining effluents, lumbering, and pulpmill wastes.

The Federal MAREP research concerned with pollution and baseline studies is centered on concentrations of oil, trace elements, radioelements, and other toxic contaminants. The Coast Guard has devoted top priority to oil pollution baseline studies and to developing analytical capability for monitoring. Emphasis has been placed on shipboard analysis, but studies include laboratory capability for investigating natural oil seeps as well as the shipboard data collection from the Coast Guard fleet. Part of the baseline study is directed at construction of a harbor oil pollution index. AEC has directed its research toward determining the influence and movement of radioelements through the marine environment and monitoring of radiation through the food chain to man. NOAA is studying the cycling of trace elements in the estuarine and marine environment with emphasis on toxic contaminants and conducts quality control of marine fishery products with the objective of protecting the fishing industry and the consumer. Toward this objective the program goals include: to delineate and monitor the nature and extent of contaminants in fish and shellfish; to determine the feasibility of removing contaminants from fishery products; and to define the patterns of consumption of fishery products.

GEOGRAPHIC AREAS OF SPECIAL INTEREST

The coastal zone, Great Lakes, and the polar regions require special approaches due to complexity of coastal processes and other phenomena such as the behavior of ice and the extreme conditions in high-latitude ocean areas. Interest in areas like the Great Lakes develops because of their importance to the national economy or unusual research opportunities. These geographic areas are included to provide a perspective that differs from the conventional classification by discipline, agency, or MAREP special service.

Coastal Zone

The coastal zone transition area between the sea and the land is a region of enormous variability. It is the most dynamic environment on earth. Coastal zone research combines studies of physical oceanography, hydrology, political science, geology, geography, meteorology, biology, and engineering and also treats civil engineering, conservation, and scientific problems related to the estuarine areas.

Navy coastal research programs are mainly concerned with dynamics of coastal zone processes in order to improve the accuracy of predictions needed by Navy and Marine Corps units. Requirements for this knowledge and forecasting capability derive from various shallow-water naval activities related to riverine and mine warfare, amphibious assaults, antisubmarine warfare, charting, search and salvage, communications, and construction. The focus of coastal zone research is on the energy sources and response mechanisms of the shore and on sediment and coastal water circulation systems. Of special interest (because of the potential operational problems) are deltaic and estuarine processes, including mixing of salt and fresh water, tidal behavior, current generation, changes in bottom conditions, and propagation and modification of waves. Acquisition and prediction of navigational information are especially important. The understanding of the relation

between meteorological conditions and sea state, fog, winds, and surf in the coastal zone is no less important than information obtained directly from this research.

Refinement of techniques for data acquisition is sought through a Navy program of research on remote sensing. Experiments, field tests, and theoretical studies deal with assuring the Navy of, by indirect measurement, accurate, meaningful data on nearshore water depths, surf and wave conditions, river mouth and tidal inlet configurations, water temperature and salinity, current pattern and velocity, beach slopes and trafficability, and other important coastal zone properties.

Search, salvage, and recovery form an integral part of naval activities. Usually they are in the coastal zone and require special technical data and substantial environmental information. Environmental predictions supplemented with direct or remotely sensed data are required for selecting search strategies and equipment and assisting the probability of success.

Like other users of the coastal zone, the Navy recognizes its responsibility to maintain the quality of the ocean environment. Baseline studies provide a measure of the present ocean environmental quality. Hydrodynamic models demonstrate effects of proposed changes, such as added pollutants or dredging.

Research relevant to MAREP is supported also by the Army Corps of Engineers through its Civil Works Program. Areas of investigation include coastal ecology, aquatic plant control, environmental data collection, wind waves, shore processes, and dynamics of flow through inlet and estuarine regions. In FY 1972 the Corps instituted a research program on spoil disposal, which constitutes a major problem in the maintenance of navigable waters. The Corps serves as lead agency for an interagency committee studying the Louisiana coast and for another committee developing a comprehensive resource study of Chesapeake Bay. The Chesapeake Bay study includes design and development of a physical model to be located in Maryland. In addition, the Corps is conducting environmental studies on the Chesapeake and Delaware Canal, San Francisco Bay, and Trinity Bay, utilizing physical models to evaluate the impact of sedimentation and other changes on each ecosystem.

The Coast Guard, through its Office of Research and Development, conducts experiments to measure advection and diffusion of floating and suspended pollutants in U.S. coastal waters. Processes to be studied include Ekman circulation, Langmuir circulation, and thermohaline instability. In addition, water movement information will be provided for several major harbors in support of Harbor Pollution Contingency Plans. The leeway and diffusion of various types of oil under varying wind and sea conditions will be studied to improve the Coast Guard's prediction of movement and fate of oil spilled at sea.

NSF, through its Environmental Systems and Research Division, sponsors programs on MAREP research in coastal and estuarine areas, and the Regional Environmental System Program of its Division of Environmental Systems and Resources is aimed at better prediction of the consequences of regional growth and better understanding of alternative methods of resource development and strategies of waste management. Studies are being carried out in coastal zones such as the Chesapeake Bay and Delaware Bay. Coastal upwelling areas bringing up colder, nutrient-rich water are estimated to produce 50 percent of the world's fish supply (fig. 11). Determinations are also being made of the effects of selected toxic trace contaminants on animal and plant communities.

The objective of the Living Resources Program in the International Decade of Ocean Exploration (IDOE) is to improve understanding of biological processes so that living marine resources can be more intelligently utilized. The major experiment under this program is the Coastal Upwelling Experiment (CUE). Field work is complete in selected areas off the west coast of the United States. In FY 1974 a field program, JOINT I, as sponsored by the IDOE's Living Resources Program (fig. 12), is scheduled to take place off the west coast of Africa. In this multi-institutional experiment, physical and biological oceanographic studies are combined to develop predictive mathematical models of an upwelling system. Because upwelling brings nutrients to the ocean surface, upwelling regions are rich fishing areas. The Living Resources program was funded at $1,260,000 in FY 1973, with an expected increase of $490,000 in FY 1974.

The Department of Commerce plans continued research in estuaries and the coastal zone for FY 1974. Research projects, conducted by NOS, NMFS, and ERL of NOAA, include work on estuarine flushing and on physical processes along coasts and in estuaries, and their effects on living resources.

A major new initiative of NOAA is the Marine Ecosystem Analysis (MESA) program. A NOAA plan for MESA has been developed to provide a concerted effort in key coastal areas by Federal and State agencies and the academic community to develop information necessary for the rational management of the coastal zone. The objectives of the MESA plan are:

- To describe, understand, and monitor the phys-

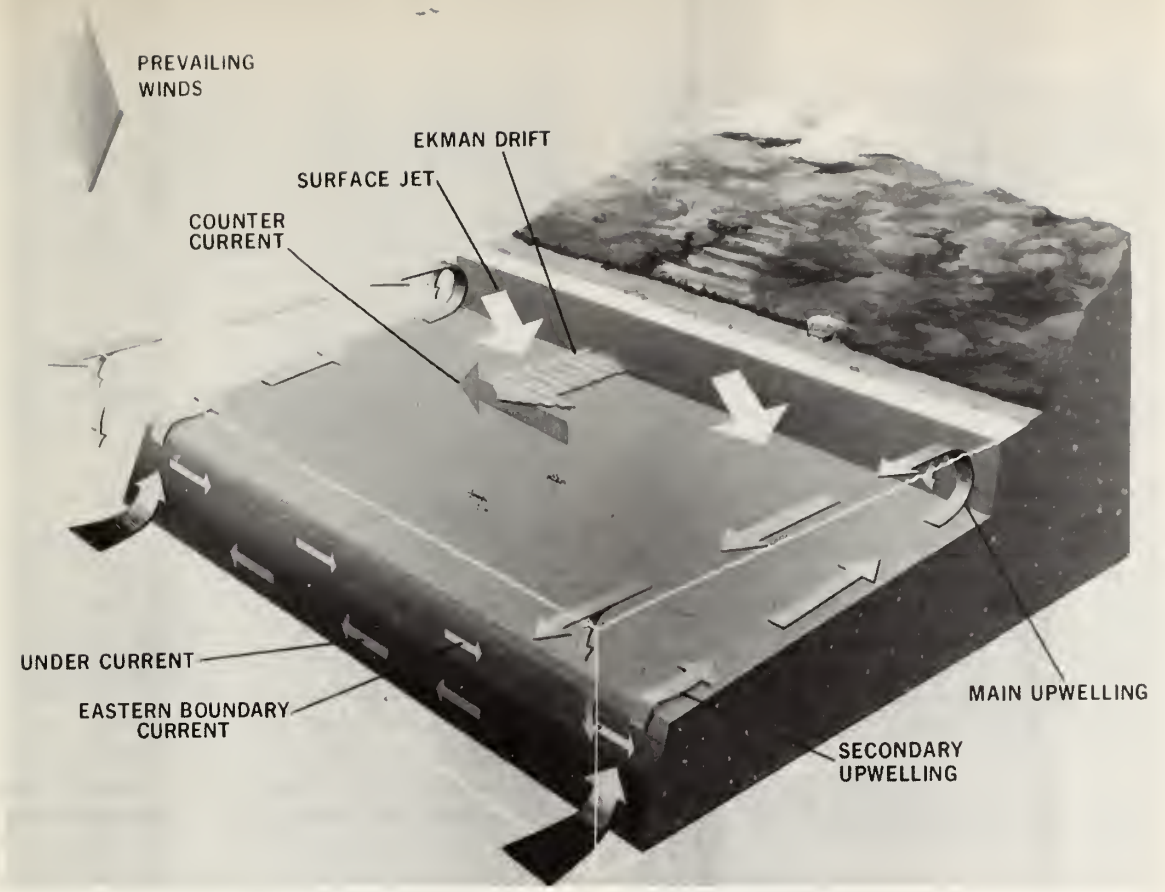


Figure 11.—Model of a coastal upwelling area.

Figure 12.—For JOINT I aircraft, ships, and buoys will provide data on the biological and physical aspects of coastal upwelling off the West Coast of Africa in 1974.

ical, chemical, and biological processes of marine environments.

- To provide information and expertise required for effective management of marine areas and rational use of associated resources.
- To analyze the impact of natural phenomena and manmade alterations on marine ecosystems.

The MESA program draws on most of the elements in NOAA to form an effective and coordinated approach to the understanding of marine environmental processes. The program will provide comprehensive sampling and measurement of circulation patterns, tides, estuarine flushing, water-mass exchanges, physical and chemical properties, and sediments as they relate to the understanding, maintenance, and enhancement of the marine environment. MESA will focus on selected marine areas needing immediate attention because they have already been seriously damaged or are threatened by projected developments. The New York Bight has been selected as the first study area. The regional project in New York Bight will be accomplished in four phases:

1. Systems analysis and design to determine the origin and fate of pollutants will be completed by FY 1975.
2. Early warning systems will be established in FY 1974–75.
3. Models for predicting modification of the environment will be completed during FY 1974–76.
4. Activities will be undertaken to stimulate regional and State participation and assumption of responsibility for programs in their areas of jurisdiction (FY 1973–76).

NOS is using empirical techniques in the development of estuarine circulation models. Predictions of flushing times for Penobscot Bay of Maine have been provided since 1968 based on simple numerical techniques. An analytical study is underway on the examination of explicit tidal effects in the estuarine mixing process in order to gain insight into the meaning and magnitude of the coefficients of turbulent diffusion. The basic work of coding the mathematical equations for a simple numerical model is complete, with work continuing to bring the model to final form.

The Office of Sea Grant within NOAA is supporting at academic institutions a number of MAREP-related projects that involve research in the coastal zone and estuarine regions on both coasts of the United States, in the Gulf of Mexico, and in Alaskan and Hawaiian waters.

Through the U.S. Geological Survey, the Department of the Interior sponsors research relevant to MAREP including estuarine hydraulics, changes in water quality, sediment transport and deposition, thermal dispersion and its effects, use of remote-sensing techniques, salt water intrusion and underground encroachment, tidal discharges, relation of streamflow to salinity, and effects and distributions of wastes introduced into coastal water bodies. Field studies are underway in Tampa Bay, Fla., in cooperation with the Tampa Port Authority, and in San Francisco Bay. The broad objectives of these studies are to understand and describe the circulation patterns of the water and relate them to sediment distribution and the transport of dissolved constituents including nutrients and trace metals.

Chesapeake Bay

The Chesapeake Bay Center for Environmental Studies, Smithsonian Institution, initiated a long-term ecosystem study of the Rhode River estuary involving scientists from the National Museum of Natural History, the Radiation Biology Laboratory, and various institutions. The goals of this research program, partially funded by NSF, are to identify the role of environmental factors in the ecosystem and to determine the effects of environmental fluctuations on ecosystem stability. These investigations will help identify those parameters most sensitive to changes in environmental conditions and will improve our understanding of the causal relationships in such systems, which is required for successful environmental prediction. Research projects include ground-truth evaluation of remote sensing and other aerial photographic techniques.

Great Lakes

The NOS Lake Survey Center of NOAA conducts studies of water motion, water characteristics, water quantity, hydrology, and ice and snow in the Great Lakes region. The primary objective of this research is to determine the present conditions of the Lakes and to define and quantify interrelations among the natural processes in the water masses and at the air-water and water-sediment interfaces. Understanding of these relations forms the basis for forecasting trends and for determining effects of manmade changes. Research consists of field surveys, data processing, analysis, model formulations, and information dissemination through publication of reports and papers.

The Lake Survey Center carries out research studies on waves, tides, surges, seiches, currents, energy exchange at the air-water interface, and flows in the Great Lakes and associated channels. From these studies mathematical models and statistical relationships are derived. These models are then used to predict changes in these natural processes as they

affect management and maintenance of beaches, layout and maintenance of navigational channels, and design of harbors and locks. The output from this program takes the form of research papers and reports, wave frequency charts, water level atlases, and predictions of harbor currents and abnormal water level disturbances. Also, the Lake Survey Center collects, analyzes, and interprets data pertaining to the physical and chemical characteristics of water in the Great Lakes in order to determine their present condition. These studies involve monitoring radioactive contamination, temperature, and other parameters; defining those water properties which could be used as water quality indexes; designing and installing monitoring stations; and monitoring water quality variations and identifying their causes.

The energy and chemical budgets are determined to identify the dynamic properties of the Lakes and to help explain evaporation and water balance, lake currents, and ice formation and decay.

Better understandings of time-space distributions and interrelationships of these physical and chemical properties and their variations result in better forecasts for multiple-use management of Great Lakes waters. Baseline data furnish information needed in evaluating engineering development projects and are basic inputs to mathematical models simulating the natural environment. The principal outputs from these studies are research papers, reports of tabulated data, and charts depicting seasonal distributions of water characteristics.

The limnologic systems research is aimed at development of process-response models to simulate the complex interrelationships between the individual processes within the Great Lakes and their immediate environment. These models will provide the basis for optimum utilization of water resources, stress and disaster predictions, and statistical analyses of random events.

A hydrologic response model has been developed for Lakes Michigan, Huron, and Erie. The model parameters include overlake precipitation, tributary inflows, lake evaporation, flow diversions, connecting-channel discharge equations, and lake regulation plans. At present this model is being used to prepare 6-month forecasts of lake levels and 15-day forecasts of navigation depths at critical locations. The model will be expanded to include Lakes Superior and Ontario.

The International Field Year for the Great Lakes (IFYGL) is a joint United States-Canadian study of Lake Ontario and is part of the International Hydrological Decade. NOAA has been designated the U.S. lead agency for IFYGL. Also participating are the Departments of Defense, Interior, and Transportation, and EPA and NSF. NSF is contributing to IFYGL through support of university scientists and use of aircraft from the National Center for Atmospheric Research which is making special flights over Lake Ontario during the Field Year. EPA is responsible for project planning, field surveys and monitoring programs, model development, and data management, analysis, and interpretation in connection with the chemical and biological program. EPA grants initiated in FY 1973 supported specific projects in biomass and chemical monitoring, nutrients cycling, data analysis, and model verification.

The goal of IFYGL is to determine best use of available fresh water supply for domestic consumption, industrial usage, navigation, power, and recreation. The primary objective of IFYGL is to investigate problems associated with hydrology, meteorology, physical limnology, and geology of a large lake. Many of the agency research projects will be conducted by university investigators under contract. The intensive, coordinated data collection program of IFYGL was completed on March 13, 1973, and data analysis will continue after that date. The types of studies are outlined below.

Hydrological studies:
—Terrestrial water balance
—Atmospheric water balance
—Evaporation synthesis
—Lake levels
—Tributary levels
—Water level simulation

Limnological studies:
—Lake heat budget
—Flow-transport synthesis
—Atmospheric boundary layer
—Lake biological and chemical processes
—Coastal circulation
—Tributary streamflow and diffusion
—Material balance, lake and selected tributaries
—Lake circulation and diffusion
—Lake biological and chemical status
—Fish populations
—Coastal biological and chemical status and processes
—Tributary biological and chemical status and processes
—Simulation of biological and chemical processes

Special studies:
—Surface waves
—Coastal levels, surges and seiches
—Lake ice processes
—Lake-effect storms.

In the Department of the Interior, the Bureau of Sports Fisheries and Wildlife conducts a research program on fish population assessment and characteristics of the Great Lakes. Objectives of this research are:

- To determine changes in fish stock in various areas of each lake, particularly changes in abundance, size, composition, and age; and to monitor fish stocks annually in different parts of each lake.
- To study seasonal, annual, and long-term changes in major fish-producing environments of the Great Lakes through continued and intensive sampling of physical, chemical, and biological conditions.

The Corps of Engineers is lead agency for extension of the navigation season on the Great Lakes. In this capacity it has formed an interagency committee composed of representatives of the Federal and State agencies having an interest in this program. Part of the effort will involve marine prediction services and developing technology for control of icing.

In the Great Lakes, the Coast Guard is conducting research connected with extending the navigation season. These experiments deal with ice navigation, icebreaker design, ice formation, and ice reconnaissance. Individual projects include:

- Instrumenting icebreakers with strain gages to measure ice forces on ships' hulls.
- Measuring physical properties of lake ice, including ice strength, thickness, temperature, snow cover, snow friction and windrow formation.
- Developing a follow-the-wire navigation system for ships entering narrow ice-infested channels. This technique incorporates an energized electrical cable on the lake bottom and associated sensing apparatus on the vessel.

The Arctic

For many years the Navy has emphasized research in the Arctic as one of the world's great unexplored regions and as a strategically important area. Recent oil discoveries on the Alaskan North Slope have increased the need to understand and predict this climatically hostile environment.

Arctic ocean science shares the basic objectives common to naval and national interests around the world. The Navy's main objective is to acquire a comprehensive body of scientific and engineering knowledge essential to naval operations in the Arctic Ocean and its approaches.

The Navy-owned contractor-operated Naval Arctic Research Laboratory (NARL) is located at Barrow, Alaska. Since its inception in 1941, NARL has been the only U.S. laboratory devoted full-time to support of Arctic research. Its position on the shores of the Arctic Ocean at the northernmost limit of the United States presents unique opportunities to attain Arctic research objectives.

From NARL the Navy operates several field stations, including some on an ice island. Research at these stations includes measurement programs in geophysics (gravity, magnetics, underwater acoustics, seismology), micrometeorology, physical and chemical oceanography, sediment studies and heat flow measurements, ice physics, and ice drift. These programs have been supplemented by airborne studies of pack ice distribution and dynamics.

An ice surveillance program collects data concerning the distribution of various ice features and conditions. The project BIRDSEYE uses airborne visual instrumentation to provide intelligence on large-scale behavior. Among the sensors are infrared scanners and laser altimeters.

A special case of polar air-sea interaction arises where there is ice cover, either permanently or intermittently. Energy exchange among sea, ice, and the atmosphere is under investigation to determine meteorological and climatological periodicities and to provide data necessary for reliable predictions and forecasts.

These and other Arctic programs have contributed to knowledge of Arctic basin geology and crustal structure; rates of ice formation; dissipation, deformation, and drift; and underwater acoustics. These investigations have produced many practical applications, including improved survival techniques, aircraft landings on ice, use of ice for camp construction, over-ice vehicular movements, icebreaking, ice forecasting, ice penetration by submarines, and bathymetric charts of the Arctic Ocean.

The Department of the Interior's Geological Survey will continue its participation in the Arctic Ice Dynamics Joint Experiment (AIDJEX) through planning, analyzing, and interpreting the results of imagery obtained from NASA, Navy, and Coast Guard aircraft on Arctic overflights and imagery from TIROS satellites. Future work will also deal with passive microwave images obtained from Nimbus satellites and other sources of data, notably SKYLAB. The particular purpose of these studies is to understand the large-scale behavior of sea ice and the relation of the Arctic ice cover to continental climates.

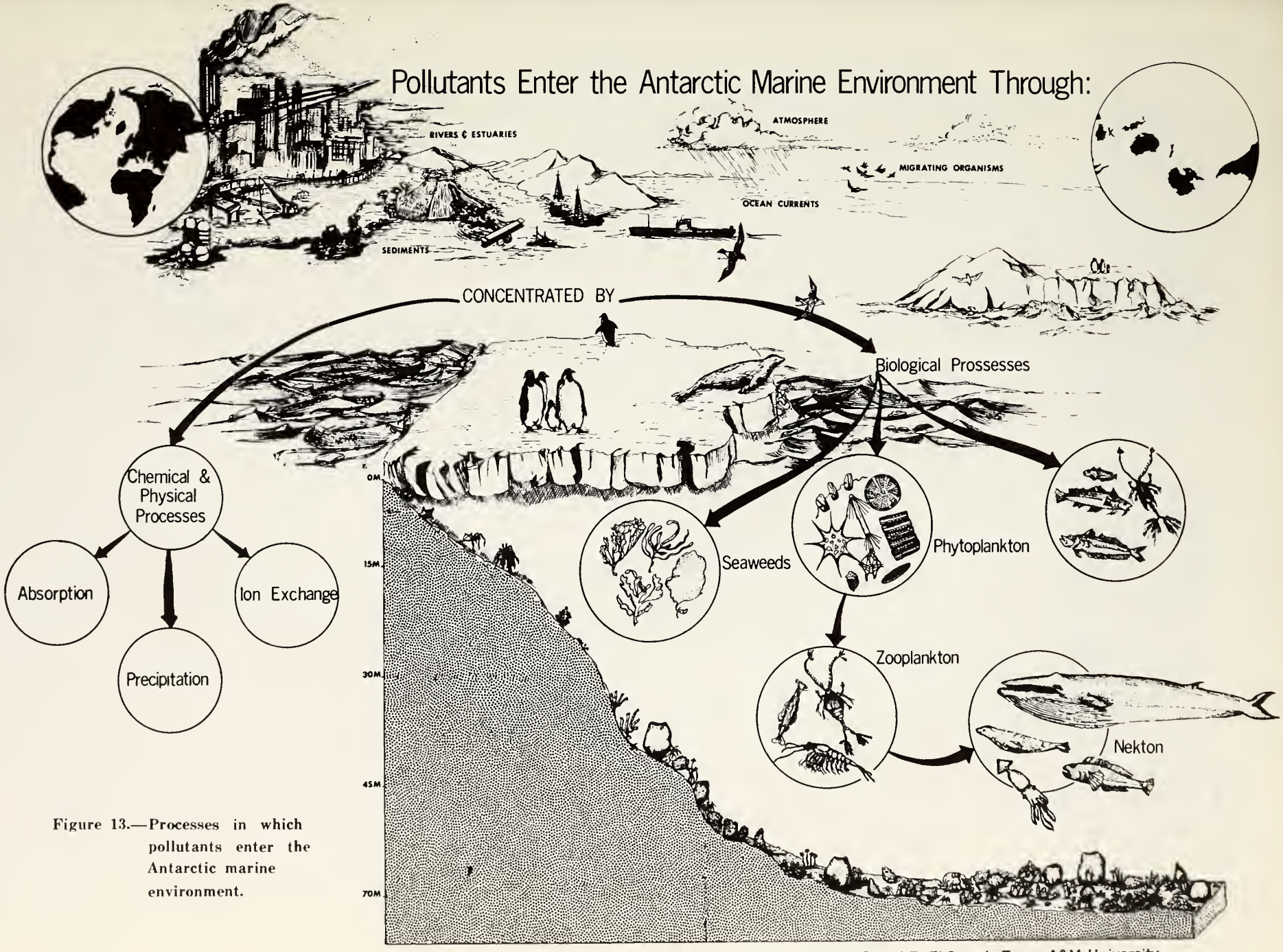


Figure 13.—Processes in which pollutants enter the Antarctic marine environment.

Courtesy of Dr. Sayed Z. El-Sayed Texas A&M University

The Antarctic

The U.S. Antarctic Research Program, sponsored by NSF, is directed toward advancement of international scientific cooperation and greater understanding of the Antarctic environment and related phenomena. The biological programs are designed to increase knowledge of the Antarctic marine ecosystems for the potential development of living marine resources. Physical oceanographic studies are also made by oceanographic institutions with the objective of understanding the influence of the heat budget of Antarctic waters on world climates. In FY 1974, plans will be made for an inter-institutional study to learn more of the pollution dynamics in the southern ocean and the Antarctic sea-ice zone. (See fig. 13).

☆ U. S. GOVERNMENT PRINTING OFFICE : 1973—542-650/56

PENN STATE UNIVERSITY LIBRARIES
A00007204152 9